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NOTE. On 31 March 1949 the Discovery Committee was wound up, and the Discovery Investigations were taken over by the National Institute of Oceanography. The Institute accepted responsibility for the publication of pp. 113-314 of the present volume, and will continue to issue further parts in the *Discovery Reports*.

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ANTARCTIC PYRENOCARP LICHENS

By I. Mackenzie Lamb, D.Sc.

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INTRODUCTION

The number of species of Pyrenocarp lichens at present known to occur in the Antarctic is twenty, the genera represented being *Verrucaria*, *Thelidium*, *Staurothele*, *Microglaena*, *Dermatocarpon* and *Mastodia*. The genus *Endocarpon* has also been recorded (see p. 26), but its occurrence is doubtful and cannot at present be verified. Of these genera, *Microglaena*, *Dermatocarpon* and (technically) *Staurothele*[1] had not been previously recorded from this region. The material upon which the present study is based is mainly that collected by: (*a*) the Discovery Expeditions of 1931–3, 1933–5, and 1935–7; (*b*) the British Graham Land Expedition of 1934–7; and (*c*) the Falkland Islands Dependencies Survey (during the period 1944–6), with which I served in the capacity of Botanist. In addition, the material collected by the following earlier expeditions has been revised and included in this paper: (*a*) James Clark Ross's 'Erebus and Terror' Expedition of 1839–43; (*b*) the Belgian Expedition of 1897–9; and (*c*) the Swedish Expedition of 1901–3.

In connexion with these studies, I should like to express my thanks to the authorities of the following institutions: (*a*) the British Museum (Natural History), London, for a grant of money and special leave whereby I was enabled to study the material in the Vainio collection at Turku, Finland; (*b*) Turun Yliopiston Kasvitieteellinen Laitos, Turku, for all facilities placed at my disposal during my study of the material of the Belgian Expedition there in 1937; and (*c*) the Naturhistoriska Riksmuseet, Stockholm, for the loan of some of the specimens collected by the Swedish Expedition. I am also grateful to my colleagues of the Falkland Islands Dependencies Survey, Major Andrew Taylor, Lieut. E. H. Back, Lieut. D. James, and Capt. V. Russell, for assistance in the collection and observation of lichen specimens during the sledging trips, and to my friend Dr Rolf Santesson of Uppsala for the benefit of his help and advice on the ecological terminology of the marine species.

HISTORICAL SURVEY OF LICHENOLOGICAL WORK IN THE ANTARCTIC

A good general account of botanical exploration in the antarctic regions has been published by Skottsberg (1940). A brief survey of the lichenological field work done by the various expeditions is appended here, and the map on p. 4 shows the localities in the Graham Land sector where lichen collections have been made.

The first recorded collection of lichens from south of 60° lat. is that of James Eights, who visited the South Shetlands in 1830. His scientific work there has been reviewed by Calman (1937).

The 'Erebus and Terror' Expedition of James Clark Ross, which visited the Antarctic in the years 1839–43, was accompanied by the famous botanist J. D. Hooker. His antarctic collections were made on Cockburn Island, a small island of basalt and agglomerate lying in the Erebus and Terror Gulf on the east side of the Graham Land peninsula. A preliminary list of these lichens was published by Hooker and Taylor (1844), and a more comprehensive enumeration of nine species, in Hooker's *Flora Antarctica* (1845–7).

[1] Already recorded under the old comprehensive generic name *Verrucaria* by Hooker (1845–7).

Dumont d'Urville visited Adélie Land in 1840, and landed on a rocky islet off the coast in the neighbourhood of 'Pointe Géologie'; he collected rock specimens, but 'of vegetation nothing was seen' (according to Fricker, 1900).

Fig. 1. The Graham Land peninsula and adjacent islands, showing localities where collections of lichens have been made.

A lapse of over 50 years now intervened until in 1895 Borchgrevink landed from the steam whaler 'Antarctic' on Possession Island and Cape Adare, in South Victoria Land, and collected one species of lichen (see Fricker (1900), where further references are given).

The first comprehensive lichen collections were made by the Belgian Antarctic Expedition of 1897–9. Fifty-five species of lichen were collected on the west coast of the Graham Land peninsula, and sub-

sequently classified by Vainio (1903). Twenty-eight of these species and one lichen parasite proved to be new to science, together with several varieties and forms.

The 'Southern Cross' Expedition of 1898–1900, led by Borchgrevink, carried out scientific work in South Victoria Land, and a few lichens were collected in what was then known as Geikie Land, not far from Cape Adare. The official scientific report of this expedition was published by the British Museum, and in it four species of lichen, all previously known, were recorded by Blackman (1902). This material is preserved in the British Museum herbarium. Other lichen material collected by the same expedition was submitted to Prof. Th. M. Fries, who also enumerated four species (1902), with one new form of *Lecanora chrysoleuca*. This material is presumably in Th. Fries's herbarium at Uppsala.

In the year 1901 three independent expeditions left for the Antarctic: (*a*) the British National Antarctic Expedition; (*b*) the Swedish South Polar Expedition; and (*c*) the German South Polar Expedition.

The British National Antarctic Expedition of 1901–4 brought back a collection of lichens from the region around the McMurdo Sound in South Victoria Land, partly from near the winter station of the 'Discovery' and partly from altitudes of 500–1600 m. on Mt Terror and in the West Mountains at the head of the Ferrar Glacier. In this collection Darbishire (1910) identified twenty-four species of which five were new to science. The material is preserved in the box collection of the British Museum.

The Swedish South Polar Expedition of 1901–3 reached the South Shetlands in 1902, and lichens were collected by the eminent botanist and phytogeographer Carl Skottsberg both there and along the Gerlache Strait and the eastern side of the Trinity Peninsula. Unfortunately, much of the scientific material was lost when the 'Antarctic' was crushed in the ice in 1903, but a number of specimens, including lichens, were preserved, in conditions of great hardship and difficulty, throughout the enforced sojourn of the party on Paulet Island until they were relieved the following season. The lichens were dealt with by Darbishire (1912). Species from south of 60° lat. numbered forty-six (plus one lichen-parasite), of which nine were new to science. This collection, apart from a few duplicate specimens in the Kew Herbarium, is at the Naturhistoriska Riksmuseet in Stockholm. Some of Darbishire's new species have been redescribed by Zahlbruckner (1917) and Magnusson (1929).

The German South Polar Expedition of 1901–3 visited Kaiser Wilhelm II Land in what is now the Australian Antarctic Territory. Three lichens were taken from the Gaussberg, and were subsequently identified by Zahlbruckner (1906), who found one of them to be the type of a new variety. They were preserved at Berlin-Dahlem.

Simultaneously with the Swedish and German Expeditions, the Scottish National Antarctic Expedition of 1902–4 was working at the South Orkneys, and several lichens were brought back from there to be named by Darbishire, who recorded eleven species, one of which, a fruticulose *Placodium*, was considered to be new at the time (Darbishire, 1905), but subsequently found to be identical with Vainio's *P. regale* (Darbishire, 1912*a*). I have not succeeded in discovering the whereabouts of this collection, but Prof. R. N. Rudmose Brown kindly sent to the British Museum a few previously overlooked unnamed specimens gathered by this expedition, of which he was a member.

In 1903 Dr Charcot took the field with the first French Antarctic Expedition. This returned in 1905, after wintering at Booth (Wandel) Island in the Kaiser Wilhelm II Archipelago. A small collection of lichens was made and submitted to the Abbé Hue for identification. Of the sixteen species present four (and a lichen-parasite) were considered to be new (Hue, 1908). I saw some of the type material at the Muséum d'Histoire Naturelle, Paris, in 1936.

At least one lichen was collected in the South Orkneys by a visitor named Edgar Szumla in 1904. This information is derived from the recent publication by Frey (1936) of a new variety of *Umbilicaria Dillenii* based on this collector's material from there, and present in the Berlin Museum.

The next expedition to visit the Antarctic was Shackleton's first British Antarctic Expedition of 1907–9. A base was established at Cape Royds in McMurdo Sound, South Victoria Land. Mt Erebus (about 4250 m.) was ascended, and both geological and botanical collections were made. These included thirteen lichens, of which a list, including one new species, was published by Darbishire (1923). I have not been able to trace this interesting collection.

Charcot's second French Antarctic Expedition of 1908–10 was organized with very complete provision for scientific research. Numerous landings were made along the western coast of the Graham Land peninsula, and rich biological collections brought in. The lichens were subsequently examined by Hue, whose report on them (1915) enumerates 112 species, of which no less than ninety were supposedly new to science. This apparent preponderance of endemic species has since been found to be to a large extent illusory, being due to Hue's inelastic conception of the species concept and his failure to allow for ecologically conditioned variation. The material, for the most part brought back *in situ* on large blocks, unfortunately appears to have been lost; a search for them at the Muséum d'Histoire Naturelle, Paris, in 1936 brought to light only a few of the smaller specimens which had been incorporated in the general lichen herbarium.

It is known that botanical specimens were collected in King Edward VII Land by Lieut. Prestrud of the Norwegian Antarctic Expedition of 1910–12, but apparently no account of the lichens has ever been published.

Scott's last British Antarctic Expedition of 1910–13 brought back seventeen species of lichen from Cape Adare and Evans Coves in South Victoria Land. They were treated by Darbishire (1923*a*) who found eight of them to be new to science. They are preserved at the British Museum, partly in the herbarium and partly in the box collection.

Mawson's Australasian Antarctic Expedition of 1911–14 carried out biological investigations in Adélie Land and Queen Mary Land. According to Dodge and Baker (1938), the report on the lichens still awaits publication.

In the years 1914–17 Shackleton undertook his second, or Transantarctic Expedition. The party was marooned on Elephant Island in the South Shetlands, and two lichens collected from there were named by Darbishire (1923).

The Shackleton-Rowett Expedition of 1920–2 again visited Elephant Island, and a lichen was noted on some of the rocks (Wild, 1923, p. 335). The specimen, now in the British Museum, is a *Neuropogon*.

Mention should be made here of several small collections of lichens made in the South Orkneys and Shetlands by A. G. Bennett on various occasions between 1913 and 1925, and presented by him to the British Museum.

A series of Norwegian expeditions were made in the years 1926–37 under the direction of Consul Lars Christensen, and the Antarctic coast was visited in various sectors. The scientific material collected will, it is understood, be published by the Norwegian Academy of Science.

Adm. Byrd's first American Expedition of 1928–30 visited King Edward VII Land and South Victoria Land. According to Dodge and Baker (1938), no report on the lichens has yet been published.

The British Australian and New Zealand Antarctic Research Expedition of 1929–31 worked mainly on the subantarctic islands of the Southern Ocean, but landings were also made on the Antarctic continent in Adélie Land and MacRobertson Land and some lichens collected there. The material is being identified by Prof. Carroll W. Dodge.

Rich collections of lichens from the South Orkneys and Shetlands were made during three of the expeditions of the R.R.S. 'Discovery II' in the years 1931–3, 1933–5, and 1935–7, and were presented to the British Museum. Some of them are dealt with in the present paper.

The second American Antarctic Expedition of 1933–5 visited Marie Byrd Land, King Edward VII

Land, and South Victoria Land. An unusually large collection of cryptogams was made by trained biologists. The lichens were subsequently studied by Dodge and Baker, who (1938) identified eighty-nine species, of which no less than eighty-four were new to science. This remarkable degree of endemism (even allowing for reduced forms which may eventually prove to belong to already known species) may seem surprising, but it must be remembered that most of the collections were made in hitherto unvisited regions. The types are preserved at the Missouri Botanical Garden, St Louis, U.S.A.

The British Graham Land Expedition of 1934–7 worked along the western coast of Graham Land south to Alexander Land, which was found to be much more extensive than was previously supposed. Large and fine collections of lichens were made, and particular attention was paid to their ecological relationships. The material has been presented to the British Museum, and has been used in the compilation of the present paper.

In 1938 a German Antarctic Expedition, under the command of Capt. Ritscher, left Germany for the Antarctic on the 'Schwabenland'. A staff of scientists was carried, and biological collections were made on the Antarctic continent around the zero meridian, i.e. in the Queen Maud Land sector. The expedition returned to Germany in April 1939. A preliminary account of the scientific results was published in 1939 in the *Annalen der Hydrographie und maritimen Meteorologie* (according to the *Polar Record*, IV, no. 31, 1946).

The third American Antarctic Expedition under Adm. Byrd spent the years 1939–41 in the exploration of the regions between Marie Byrd Land and Alexander Land. Two bases were established, a western near Little America in the Bay of Whales, and an eastern on Stonington Island in Marguerite Bay, west Graham Land. Several sledging parties traversed the Graham Land peninsula; one of them followed the east coast of the peninsula southwards to lat. 70° 51′. Another party reached the Eternity Range, discovered by Lincoln Ellsworth. King George VI Sound was found to separate Alexander I Land completely from the mainland. Botanical collections were made from both the western and the eastern bases. Much of the material collected at the eastern base, however, had to be abandoned owing to the emergency evacuation of the personnel by air, but a representative selection of botanical specimens was taken. Lichens were also collected in the Melchior Islands in Dallmann Bay. The material is being studied by Prof. Carroll W. Dodge.

Finally, the Falklands Islands Dependencies Survey,[1] sponsored by the British Colonial Office, established three bases in the Graham Land Sector in 1944–5: (*a*) at Deception Island, South Shetlands; (*b*) at Port Lockroy, Wiencke Island (in the Palmer Archipelago); and (*c*) at Hope Bay on the Trinity Peninsula, a locality already visited in 1902 by the Swedish Expedition. Intensive collecting and ecological work was done around the bases, and in 1945 two sledge journeys were made from the Hope Bay base down the east coast of the peninsula to extend the survey of the Swedish Expedition. Numerous botanical collections were made during these journeys, in many cases from islands and headlands discovered for the first time, and as yet unnamed. For this reason I will refer to these botanical localities provisionally by station numbers, indicated on the accompanying map, and listed as follows:

St. 24. Headland in approx. lat. 63° 33′, long. 57° 22′.
St. 25. Headland in approx. lat. 63° 38′, long. 57° 34′.
St. 26. Headland in approx. lat. 63° 40′, long. 57° 48′.
St. 27. Island in lat. 63° 37′, long. 57° 19′.
St. 28. Island in lat. 63° 40′, long. 57° 28′.
St. 29. Island in lat. 63° 40′, long. 57° 35′.
St. 30. Island in lat. 63° 40′, long. 57° 40′.
St. 31. Islet in approx. lat. 63° 43′, long. 57° 37′.

[1] Until the end of 1945 the Survey was known as 'Operation Tabarin'.

Fig. 2. The east coast of the Trinity Peninsula, Graham Land, showing positions of the collecting stations. (Based on the survey made by Major Andrew Taylor, R.C.E., assisted by Capt. Victor Russell, R.E., in 1945.)

St. 33. Island in lat. 63° 45′, long. 58° 10′.
St. 34. Headland in approx. lat. 63° 49′, long. 58° 20′.
St. 38. Islet in approx. lat. 63° 58′, long. 58° 36′.
St. 46. Islet in approx. lat. 63° 59′, long. 57° 23′.
St. 48. Projecting headland on south side of Vega Island.
St. 51. Site of camp on shore of James Ross Island in Sidney Herbert Sound.
St. 52. Valley on coast of James Ross Island in Sidney Herbert Sound.
St. 62. A concealed fresh-water lake on the west side of James Ross Island.
St. 66. Headland on James Ross Island, west side, in Röhss Bay.
St. 73. Headland (perhaps formerly islet) adjoining the Naze, north coast of James Ross Island.
St. 75. Locality on James Ross Island on the west side of the bay forming the southern extension of Sidney Herbert Sound.
St. 77. Headland in approx. lat. 63° 38′, long. 57° 08′.

GEOGRAPHICAL DISTRIBUTION

It has long been known that the antarctic flora includes a considerable bipolar element, consisting of species which occur also in the Arctic (with or without outlying occurrences at high altitudes in the temperate northern hemisphere). The phenomenon has been fully treated in a recent paper by Du Rietz (1940). Whether these species have originated in the Arctic and spread across the equator to the Antarctic, or vice versa, is a matter for surmise. Du Rietz (1929) is of the opinion that the area of greatest specific differentiation of a genus is most likely to be that in which it originated. If this is so, then certain predominantly antarctic and subantarctic bipolar lichen genera, such as *Sphaerophorus*, *Placopsis* and *Neuropogon*, must be of southern origin. In the Antarctic, the bipolar element is much more strongly represented in the Graham Land region than in the Ross Sea sector, the only other area of which the lichen flora is sufficiently well known to permit of any comparison. This may be due to one or both of two factors: (*a*) the lesser distance separating the Graham Land sector from the adjacent land masses; and (*b*) the existence of a more continuous montane pathway of migration, along the Cordilleran chain and the Rockies, than is available in the eastern hemisphere. There is actual evidence of Cordilleran migration in the case of *Neuropogon sulphureus* (Lamb, 1939). Among the antarctic Pyrenocarp lichens, the delimitation of the term 'bipolar' presents some difficulties. At one end of the scale there is *Mastodia tesselata*, very strictly bipolar in its distribution (subantarctic and antarctic southern hemisphere, arctic eastern Siberia). *Dermatocarpon intestiniforme* is a good representative of those bipolar species which also possess an outlying alpine areal in the temperate northern hemisphere. Of the marine species, *Verrucaria ceuthocarpa* can be regarded as bipolar, although it penetrates into temperate Europe and North America; with the other species, *V. maura*, *V. microspora* and *V. mucosa*, the extension into the temperate zone is so marked that the term 'bipolar' becomes hardly applicable.

Species apparently endemic to the Graham Land peninsula and adjacent islands are *V. cylindrophora*, *V. dispartita*, *V. elaeoplaca*, *V. famelica*, *V. psychrophila*, *V. Racovitzae*, *V. serpuloides* and *Microglaena antarctica*. The only Pyrenocarp lichens known to date from the Ross Sea area[1] are *Thelidium inaequale* and *Th. parvum*, both endemic to that region.

[1] Apart from the doubtful record of the genus *Endocarpon* by Darbishire (1910).

Verrucaria tesselatula is a subantarctic-bicentric, or perhaps circumpolar, species with an extension into the antarctic in the Graham Land sector. *Staurothele gelida* is also subantarctic-antarctic in its distribution, but apparently confined to the South American sector.

Consideration of these endemic antarctic and subantarctic species raises the question of vicarious representation, which has been touched upon by Degelius in his studies of the relationships between the lichen floras of Europe and North America (1940). He finds that in addition to vicarious species which simply replace each other in the two areas under consideration, there is a second type, for which he proposes the term 'subvicarious species', in which nearly related species almost, but not entirely, replace each other in their distribution. It is interesting to find the same phenomenon among the lichens of the northern and southern hemispheres. One of the best examples of such a subvicarious pair is furnished by the two species of *Neuropogon*, *N. sulphureus* and *N. antarcticus* (Lamb, 1939). The former is the only representative of the genus in the Arctic; the latter, very closely allied morphologically, largely takes its place in both the Falklands sector and the Ross Sea area, but *N. sulphureus* is also present, notably on the eastern side of the Graham Land peninsula. Instances of bipolar vicarious and subvicarious species among the Pyrenocarp lichens can be tabulated as follows:

Northern hemisphere	Southern hemisphere
Vicarious species	Vicarious species
Verrucaria striatula subsp. *borealis* Santesson (1939)	*Verrucaria striatula* subsp. *australis* Santesson (1939)
Verrucaria cataleptoides Nyl.	*Verrucaria Racovitzae* Vain.
Staurothele clopima (Wbg.) Th. Fr.	*Staurothele gelida* (Hook. and Tayl.) M. Lamb
Subvicarious species	Subvicarious species
Verrucaria microspora Nyl.	*Verrucaria dispartita* Vain. + *V. microspora* Nyl.
Verrucaria ceuthocarpa Wbg.	*Verrucaria tesselatula* Nyl. + *V. ceuthocarpa* Wbg.

Finally, one of the species, *Dermatocarpon lachneum*, appears to belong to the group to which the name 'cosmopolitan' or 'ubiquistic' is applied.

ECOLOGY

In respect of habitat ecology, one group of Pyrenocarp lichens (comprising chiefly *Verrucaria* and *Arthopyrenia*) is peculiar in being amphibious in the littoral zone (Santesson, 1939). Some of these, like *Verrucaria mucosa*, are plants of the upper hydrohaline, intermittently submerged by the tide; others, of which *V. maura* is a good example, are more or less restricted to the lower hygrohaline or spray zone, above the high tide level. *V. mucosa* has hitherto been regarded as one of the most marine lichens, but in this respect it is now found to be surpassed by *V. serpuloides* (p. 20), a new species of entirely marine habitat, never or only accidentally exposed to the air.

On land also many Pyrenocarp lichens are characteristic of wet situations (fresh-water species). Such are also found in the Antarctic, but there, on account of the peculiar climatic conditions, may be actually in contact with liquid water for only a short period in every season (especially *V. elaeoplaca*, p. 15). Some of the antarctic species of this hydrophyte group are also markedly nitrophilous, absorbing ammoniacal decomposition products in solution from the snowmelt water with which they are periodically inundated.

What is known of the habitat ecology of the various antarctic Pyrenocarp lichens is summarized in the following table:

I. Terrestrial species:

(*a*) Non-hydrophilous species: *Verrucaria famelica* (nitrophilous),[1] *Thelidium inaequale*,[2] *Th. parvum*,[2] *Microglaena antarctica* (nitrophilous), *Dermatocarpon lachneum*, *Mastodia tesselata* (nitrophilous).

(*b*) Hydrophilous species:

i. Nitrophilous species. *Verrucaria elaeoplaca*, *V. Racovitzae*, *V. cylindrophora*.

ii. Non-nitrophilous species. *Staurothele gelida*, *Dermatocarpon intestiniforme*.

II. Marine species:

(*a*) Species of the lower Hygrohaline (salt-spray zone). *Verrucaria ceuthocarpa*, *V. dispartita*, *V. maura*, *V. tesselatula*.

(*b*) Species of the upper Hydrohaline (intertidal zone): *Verrucaria microspora*, *V. mucosa*, *V. psychrophila*.

(*c*) Species of the middle Hydrohaline (below the lowest ebb tide level): *Verrucaria serpuloides*.

SYSTEMATIC ACCOUNT

Order PYRENOCARPEÆ

Family VERRUCARIACEAE .

Genus Verrucaria Wiggers, 1780[3]

Key to the species of Graham Land and adjacent islands

1 *a*. Excipulum entirely dark brown in section.

2 *a*. Thallus blackish, thin, filmy, not rimose; continuous or in scattered patches.

3 *a*. Spores cylindric ... ... *V. cylindrophora*

3 *b*. Spores ellipsoid.

4 *a*. Perithecia (and usually thallus) minutely scabrid under × 10 lens ... ... *V. dispartita*

4 *b*. Perithecia and thallus smooth, shining ... ... · ... ... *V. microspora* f. *frisiaca*

2 *b*. Thallus rimose or areolate.

5 *a*. Thallus black or brown-blackish, finely cracked-areolate; excipulum about 200μ diam. *V. maura*

5 *b*. Thallus glaucous-olivaceous or buff coloured, rimose or reticulate-rimose; excipulum about 450μ diam. ... ... *V. Racovitzae*

1 *b*. Excipulum colourless in section.

6 *a*. Thallus continuous, smooth, effuse or in scattered patches or sometimes almost evanescent, not rimose.

7 *a*. Perithecia not or hardly prominent above surface of thallus ... ... *V. mucosa*

7 *b*. Perithecia prominent.

8 *a*. Perithecia hemispherical to subglobose, 0·15–0·25 mm. diam.

9 *a*. Spores 18–20 × 7·5–8·0μ ... ... *V. famelica*

9 *b*. Spores 7–12 × 4–5μ ... ... *V. microspora*

8 *b*. Perithecia truncate-subconical, 0·30–0·45 mm. diam. ... ... *V. serpuloides*

[1] As far as one can judge from the remarks of Skottsberg (1912, p. 6).
[2] As far as can be ascertained from the published observations of Siple (1938).
[3] In the list of species attributed by him to this genus Wiggers does not include any belonging to *Verrucaria* in the modern delimitation.

6*b*. Thallus rimose.

10*a*. Cracks black.

11*a*. Thallus uniformly tesselate-areolate with areolae 0·5–1·0 mm. diam. ... *V. tesselatula*

11*b*. Thallus not areolate, but with gaping cracks often reticulating to delimit irregular areas of variable size (1–10 mm.) ... ... *V. tesselatula* f. *dermoplaca*

[Thallus composed of confluent microthalli separated by blackish lines and simulating large flat areolae ... ... *V. elaeoplaca* f. *glaucoplaca*]

10*b*. Cracks between areolae ± concolorous with rest of thallus.

11*a*. Areolae up to 1 mm. diam. ... ... *V. ceuthocarpa*

11*b*. Areolae larger.

12*a*. Thallus buff-brown or olivaceous-glaucescent; spores usually $14–18 \times 8–11\,\mu$; fresh-water species ... ... *V. elaeoplaca*

12*b*. Thallus olive-blackish; spores $11–13(–15) \times 6–7\,\mu$; marine species ... *V. psychrophila*

Verrucaria ceuthocarpa Wahlenberg (Fig. 3*b*).

apud Acharius, 1803, suppl. p. 22; Vainio, 1909, p. 163, 1921, p. 72; Zschacke, 1934, p. 194.

West Graham Land. *Palmer Archipelago*: Port Lockroy, Goudier Islet; east and south-east sides of islet, on basalt dykes about 1 m. above high-water level, in the rough weather spray zone; F.I.D.S., 23. iv. 1944 (no. 1227); 28. xii. 1944 (no. 2119); on granodiorite face slightly above high-water level, in the spray zone; F.I.D.S., 23. iv. 1944 (no. 1222 *pr. p.*).

Forming effuse, indeterminate, discontinuous patches. Thallus thin, olivaceous-blackish, entirely rimose-areolate, with areolae 0·3–0·7 mm. diam. The specimens more or less correspond to the typical form of the species (var. *areolatodiffracta* Vainio, 1909). Perithecia minute, not over 0·2 mm. diam., with prominent, almost hemispherical, black apex. Excipulum colourless below and at sides. Spores $9–12 \times 6–7\,\mu$.

Geographical Distribution. New to the Eu-antarctic zone; previously recorded from northern Europe, Spitsbergen, Bear Island, Novaya Zemlya, north-east Siberia, Bering Strait, Greenland, North America (Maine and Massachusetts), and in the southern hemisphere, Kerguelen (Müller Argoviensis, 1884, p. 139[1]). According to Lynge (1937, p. 13), it is the commonest marine *Verrucaria* in the Arctic.

Var. deformata Vainio

1909, p. 164.

West Graham Land. *Palmer Archipelago*: Port Lockroy, Goudier Islet; south side of islet, 0·5–1·5 m. above high-water level, on granodiorite rock face in the rough weather spray zone; F.I.D.S., 23. iv. 1944 (no. 1222); 25. iv. 1944 (no. 1223); 7. i. 1945 (no. 2190).

'Thallus sat crassus, areolatus aut areolato-diffractus, areolis difformibus, majoribus vel minoribus, saepe leviter inaequalis et habitu quasi morbosus, olivaceo- aut pallide-olivaceo- et nigricanti-variegatus, opacus' (Vainio, loc. cit.). I have not seen an authentic specimen of this variety, but if I am correct in referring the present specimens to it, the 'morbose habitus' and pale olivaceous variegation mentioned by Vainio is due to numerous algal efflorescences on the thallus caused by proliferation of the thalline gonidia. These scattered, olivaceous-greenish, soredia-like, erumpent, mealy-granulose outgrowths are 0·15–0·30 mm. diam., and in sections through the thallus are seen to be masses of gonidial algae in a state of rapid multiplication, forming pairs, tetrads, and octants, and rupturing the thalline cortex in emerging. They are not accompanied by hyphal filaments, and hence cannot be classed as soredia.

[1] Müller, loc. cit., quotes the Kerguelen locality as being 2000 feet above sea level, which makes the record seem improbable.

Var. **submembranacea** M. Lamb, n.var.

West Graham Land. *Palmer Archipelago*: Port Lockroy, Goudier Islet; south side of islet, about 1 m. above average sea-level, in the spray zone, on an almost vertical granodiorite face; F.I.D.S., 16. xii. 1944 (no. 1994).

Description. *A forma typica differt thallo tenui* (*ad* 0·13 *mm. crasso*), *submembranaceo, fere continuo* (*rimis paucis angustissimis vel pr. maj. parte tantum lineolis nigricantibus parum conspicuis indicatis*). *Thallus plagulas irregulares, ambitu saepe obsolete pallido-zonatas, demum sat late confluentes format; passim sat crebre glomerulis sordide olivaceis* (*e efflorescentia gonidiorum ortis*) *ad* 0·3 *mm. latis obsitus.*

Thallus olivaceous-blackish in the living state, smooth, matt, with very few open cracks; most of the cracks appear to have closed up and are indicated only here and there by very fine dark lines. The relationship to the typical form and the var. *deformata*, both of which occur close by, is unmistakable. Perithecia scarce, up to 0·17 mm. diam., typical; spores 10–12 × 6·0–7·5 μ.

I was unable to detect any zonational differences between these two varieties and the typical form. They occur together with *Caloplaca cirrochrooides* (Vain.) Zahlbr. and another halophile *Caloplaca* not yet determined. All of them become crusted over with salt-water ice to a thickness of 5 cm. in late May, and remain thus encased throughout the winter.

Verrucaria ceuthocarpa is closely allied to *V. tesselatula* Nyl. (p. 21); the latter differs in the paler thallus with somewhat larger areolae separated by conspicuous black cracks.

Verrucaria cylindrophora Vainio (Pl. IV, fig. 4)

1903, p. 38.

Not found in the present collections, and known only from the type locality (west Graham Land: Palmer Archipelago, Moreno Island). My reinvestigation of the holotype in herb. Vainio (Exped. Antarct. Belge, no. 196 *pr. p.*) gave the following information:

On non-calcareous fine-grained rock. Thallus extremely thin, a mere film, continuous, black, slightly shining. No visible hypothallus. Perithecia very numerous, evenly scattered, minute, up to 0·15 mm. diam., black, ± hemispherical, matt or slightly shining, not impressed or papillate at apex; ostiole invisible. Paraphyses diffluxed, indicated by faint striae in the mucilage. Asci clavate, 20–27 × 8–10 μ, thin-walled. Spores 6–7 (–8?) in ascus, in vertical polyseriate arrangement, cylindrical, straight, rounded at ends, thin-walled, 10·5–12·0 × 2·5–3·0 μ. Hymenial gelatine faintly pink with iodine.

The holotype occurred together with *V. elaeoplaca*, which indicates a habitat on fresh-water inundation surfaces.

Verrucaria dispartita Vainio (Fig. 3 *l*; Pl. IV, fig. 6)

1903, p. 38.

West Graham Land. *Palmer Archipelago*: Port Lockroy, Goudier Islet; south side of islet, on vertical rock face just above high-water level, constantly drenched with spray in rough weather; F.I.D.S., 23. iv. 1944 (no. 1222 *pr. p.*).

East Graham Land. *Trinity Peninsula, south coast*: Hope Bay; small islet in the bay, on steep rock face in the spray zone about 0·5 m. above high-tide level; F.I.D.S., 20. xii. 1945 (no. 2564 *pr. p.*).

The specimens agree well with the holotype specimen in herb. Vainio (Exped. Antarct. Belge, no. 199), upon which the following description is based.

On fine-grained non-calcareous rock. Thallus represented by very scattered minute sooty patches and spots 0·3–0·8 mm. diam., hardly 0·1 mm. thick. Surface of thallus matt, seen to be very minutely roughened (but not punctate) under × 12 lens. No hypothallus. Perithecia numerous on thalline

patches, 0·2–0·3 mm. diam., $\pm$hemispherical, black, matt (shining only where rubbed), with minutely scabrid surface like the thallus; solitary or two to three crowded together and then often concrescent. Ostiole indistinct, not papillate or impressed. Excipulum brown to dark brown in section, entire. Paraphyses dissolved, indicated by faint striae in the mucilage. Asci cylindric-clavate, $30–40 \times 8–12\,\mu$, thin-walled. Spores ellipsoid, 8 in ascus, $8–11 \times 4·5–5·5\,\mu$. With iodine, hymenial mucilage rose-pink, asci and spores yellowed.

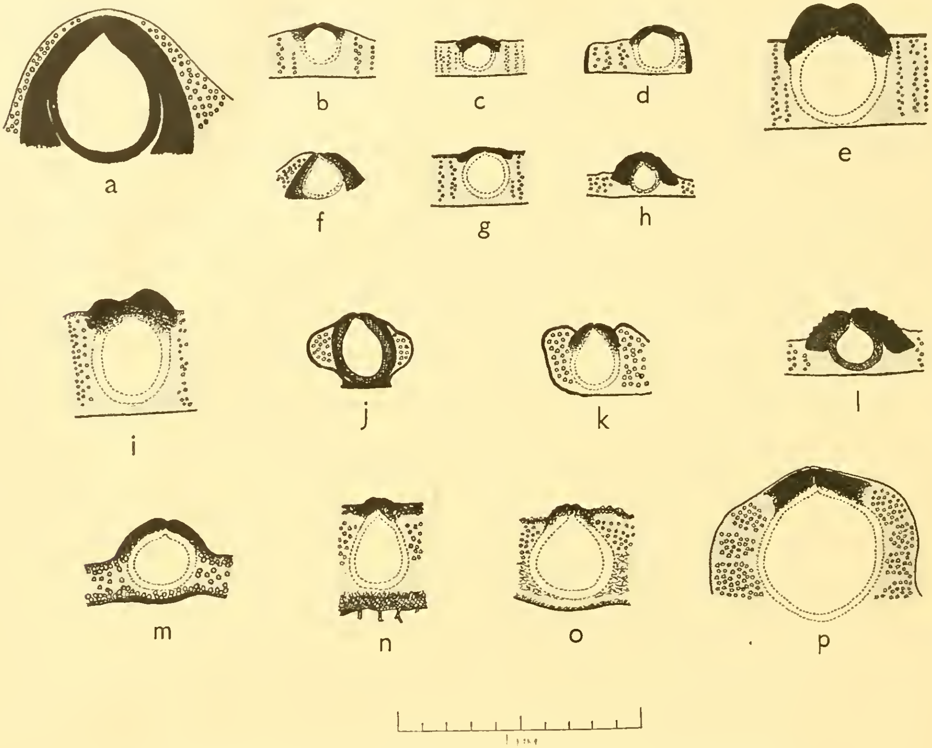

Fig. 3. Perithecial structure in Antarctic Pyrenocarp lichens. (Somewhat diagrammatic.)

a, *Verrucaria Racovitzae*.
b, *Verrucaria ceuthocarpa*.
c. *Verrucaria mucosa*.
d, *Verrucaria tesselatula*.
e, *Verrucaria serpuloides*.
f, *Verrucaria famelica*.
g, *Verrucaria psychrophila*.
h, *Verrucaria microspora* (f. *frisiaca*).
i, *Verrucaria elaeoplaca*.
j, *Staurothele gelida* (with poorly developed thallus).
k, *Staurothele gelida* (with well developed thallus).
l, *Verrucaria dispartita*.
m, *Mastodia tesselata*.
n, *Dermatocarpon lachneum*.
o, *Dermatocarpon intestiniforme*.
p, *Microglaena antarctica*.

This species comes very near *V. microspora* (f. *frisiaca*), differing only in the minutely scabrid, often somewhat cracked thallus, usually slightly roughened perithecia and the somewhat darker excipular wall. Its habitat ecology, however, is different, its occurrence being in the spray zone and not in the intertidal belt, as is the case with *V. microspora*. No. 2564 *pr. p.* was associated with *Caloplaca cirrochrooides* (Vain.) Zahlbr., in the upper part of the spray zone. In our specimens the thallus forms scattered spots or effuse, $\pm$continuous patches of small extent, it is sooty or olivaceous-blackish, about 0·1 mm. thick, continuous or with small sporadic disconnected cracks or (in no. 2564 *pr. p.*, which grew

in a drier position) with fine reticulately anastomosing cracks in the thicker parts of the thallus around the perithecia. Gonidial algae bright green, 6–8 μ diam. Excipulum spherical, (100–) 165–195 μ diam., with wall 18–21 μ thick; inner 9 μ dark brown, the outer part pale brown. Spores 9–12(–13) × 4·5–6·0(–7) μ. The minute roughening of the thallus is very inconspicuous, not to be compared with the punctate or wrinkled scabrosity of some other marine species (*Verrucaria scotina*, etc.).

GEOGRAPHICAL DISTRIBUTION. Previously known only from the type locality (west Graham Land: Cape Anna, on the mainland coast between Cape Charles[1] and Cape Renard).

Verrucaria elaeoplaca Vainio (Fig. 3*i*; Pl. II, fig. 2; Pl. III, figs. 1, 2)

1903, p. 37, pl. i, fig. 6.

Verrucaria glaucoplaca Vainio, 1903, p. 37, pl. i, fig. 5; Hue, 1915, p. 182.

WEST GRAHAM LAND. *Palmer Archipelago*: Port Lockroy, Goudier Islet; near summit of islet, altit. about 7 m. on granodiorite rocks irrigated intermittently by snowmelt water; F.I.D.S., 29. ii. 1944 (no. 1151 *pr. p.*); 26. iii. 1944 (no. 1179); 7. v. 1944 (no. 1234); 26. xi. 1944 (no. 1801); 28. xi. 1944 (no. 1833 *pr. p.*). *Argentine and neighbouring Islands*: Berthelot Islands; on dioritic rocks; B.G.L.E., 18. iii. 1935 (nos. 1081–18, 1081–25, 1090, 1094–9, 1094–10, 1094–14, 1094–46, 1094–73, 1094–84, 1095–2).

EAST GRAHAM LAND. *Trinity Peninsula, south coast*: Hope Bay; near Boeckella Lake, altitude *c.* 60 m., on non-calcareous stones half submerged in a frozen shallow fresh-water pool; F.I.D.S., 15. iv. 1945 (no. 2363).

The commonest *Verrucaria* in the Graham Land sector of the Antarctic. It is a very distinct species, without obvious affinities.

The thallus covers large continuous areas, and is not effigurate at periphery, but often bounded by a very narrow whitish zone, inside which is a thin brown-blackish line. There is no dark hypothallus. Thallus (in the typical condition) verrucose-areolate, with ± tumid and convex, irregularly obtusely angulose areolae 1·2–2·0(–3·0) mm. diam., separated by deep, incised, pale-edged cracks about 0·15 mm. wide; thickness varies between 0·3 and 1·0 mm. (rarely up to 2·5 mm.). Surface matt, smooth, not pruinose, usually pale dull buff-brown (corresponding to pl. xlvi, 17'''', 19'''' and 21''''*b* in Ridgway, 1912), in less exposed positions paler, grey-brown with a slight pinkish tinge (Ridgeway, pl. xlvi, 17''''*d*, 21''''*d*), or in very shady positions grey-greenish (Ridgway, pl. xlvi, 21''''*b–d*). In certain places where the thallus is subject to heavy inundation with water strongly impregnated with nitrogenous matter, it takes on a red tinge (Ridgway, pl. xlvi, 13''''*b*; exceptionally pl. xxxix, 9'''*a–b*), either entirely or in scattered spots and patches. In the normal brown state the thallus has a reddish brown cortex 9–15 μ deep, composed of iso-diametric, thin-walled cells 3–4 μ diam., in many places overlaid by a hyaline amorphous necrotic stratum 6–10 μ deep. In pale-coloured specimens there is no distinct cortex. Gonidial algae tend to form more or less vertical groups or rows extending through almost whole depth of thallus; bright green, subglobose or irregularly angulose, thin-walled, 6–9 μ diam. Fungal tissue between gonidia hyaline, paraplectenchymatic, of thin-walled isodiametric cells 3–4 μ diam. Lowermost 25–30 μ of thallus is without algae, hyaline, with vertically oblong cells. Perithecia numerous, but not present in all areolae of thallus; 1–4(–5) in an areola, with the convex or almost hemispherical, brown-black, matt or slightly shining apex (involucrellum) prominent above the surface and 0·2–0·3 mm. diam. Thallus not darkened around perithecia. Ostiole usually visible under lens as a fine central pore. Excipulum immersed, globose, 290–345 μ diam., with colourless wall 30–35 μ thick formed of tangentially running hyphae 1·5–2·0 μ thick; at the apex, where it merges into the involucrellum, the excipular wall becomes brownish.

[1] The northern extremity of Hughes Bay, in future to be called Cape Sterneck.

Involucrellum dome-shaped, lying directly over the excipulum, brown-blackish, of ± uniform thickness (45–60 μ). Periphyses numerous inside ostiole and upper part of excipulum; their walls gelatinized, only the slender lumina visible, simple or sparingly branched, $30–45 \times 1·5\ \mu$. Usually no paraphyses are present, but in some perithecia there are a few delicate branching hyphae 1·5–5·0 μ thick traversing the mucilage between the asci. Asci clavate or ventricose-clavate, $50–65 \times 20–30\ \mu$, with gelatinous walls up to 5 μ thick. Spores irregularly 2–3-seriate in ascus, 8, with wall about 0·6 μ thick, variable in size and shape, ellipsoid to broadly ellipsoid, $(12·5–)14–18(–20) \times (7·0–)8–11(–13)\ \mu$. Pycnidia indicated by minute punctations or brownish spots, saccate or almost flask-shaped in section, simple, 180–240 μ deep, 75–90 μ across, with colourless wall, not carbonized around ostiole. Fulcra exobasidial, subulate. Pycnoconidia bacillar, straight, $3·0–3·5 \times 0·6–0·7\ \mu$.

Chemical reactions: surface of thallus and medulla KHO-, $CaCl_2O_2$-, KHO($CaCl_2O_2$)-, $C_6H_4(NH_2)_2$-, I-. Hymenial mucilage I+ wine-red, ascus-contents and spores yellowed.

Vainio's '*Verrucaria glaucoplaca*' represents an uncommon growth-form of the species, for which reason I prefer to use '*elaeoplaca*' as the specific epithet, the type specimen of the latter being the normal state. The designation *V. elaeoplaca* f. *glaucoplaca* (Vain.) M. Lamb, n.comb., may be used for the form, occasionally met with in damper situations, in which the thallus is composed of a number of separate, contiguous, juvenile and uncracked thalli separated by dark brown lines, giving the impression of a thallus consisting of large dark-edged areolae. This is well shown on Vainio's pl. i, fig. 5. The F.I.D.S. specimen no. 1801 from Goudier Islet is partly referable to this form.

In very wet situations the thallus is more continuous (the cracks not usually anastomosing to form complete areolae) and usually with a pronounced red or pink tinge. In a fresh-water pool in the penguin rookery at Hope Bay I was able to trace the transition from the normal brown areolate condition on stones on the upper drier banks of the pool to the reddish more continuous state in the pool itself.

V. elaeoplaca is very characteristic of inundation surfaces wetted by nitrogenous snowmelt water in springtime. The photographs on Pl. III, figs. 1 and 2, were taken on Goudier Islet. In fig. 1 it is seen lining a natural gutter in the granodiorite rocks down which a steady seepage of water occurs during the melting of the islet's snow cover. Fig. 2 shows it forming a zone around the margin of a snowmelt water pool, and also bordering the run-off channel from the latter. The snowmelt water is highly nitrogenous from the excreta of birds (gulls, skuas, *Chionis alba*, etc.). Although the species is restricted so closely to inundation surfaces, the duration of actual inundation during the year is comparatively short, lasting from late October, when the snow accumulated during the winter commences to melt, till about the end of November, when in normal years the upper part of the islet should have become snowfree.

GEOGRAPHICAL DISTRIBUTION. Apparently endemic to the coast of Graham Land and adjacent islands. Previously recorded from west Graham Land: Palmer Archipelago, Moreno Island, Bob Islet (Vainio, loc. cit.) and Goudier Islet (Hue, loc. cit.).

Verrucaria famelica Darbishire (Fig. 3*f*; Pl. IV, fig. 3)

1912, p. 18, pl. 3, fig. 33.

Not found in the present collections. Known only from the type locality: South Shetlands, Nelson Island, coll. C. Skottsberg, 11. i. 1902. The following redescription of the species is based on a syntype specimen preserved in the Kew Herbarium.

On non-calcareous fine-grained rock. Thallus interruptedly covering an area of $2·5 \times 2·0$ cm., brown-blackish, thin (up to 0·1 mm. thick), effuse, indeterminate, not continuous, but composed of small confluent patches around the perithecia, with the substratum visible between; continuous or here and there slightly cracked, matt. A very fine blackish dendritic-reticulate hypothallus is visible with

the aid of a × 10 lens here and there around the thalline patches. Thallus in section with very irregular upper surface bounded by a brown-blackish cortical layer 6–8 μ thick with indistinct, ± round cells 3–5 μ diam. Most of the fungal tissue between the gonidial algae is also dark. Gonidia extend throughout whole depth of thallus, not in vertical rows; bright green, ± globose, 5–8(–12) μ diam., thin-walled, multiplying apparently by binary fission. Perithecia up to 0·2(–0·25) mm. diam., hemispherical to subglobose, black, matt or slightly shining, clothed by thallus in lower half, or in young perithecia almost to the ostiole. Ostiole apical, minute, not or only slightly impressed. Excipulum ± globose or slightly flattened, 145–210 μ diam., with faintly brownish or almost colourless wall 12–30 μ thick composed of compacted, tangentially running hyphae about 2 μ thick. Involucrellum overlaying excipulum and extending down to its base, brown-blackish in outer half to three-quarters, paler brown inside; about 30 μ thick near ostiole, up to 80 μ thick at base, not extending below the excipulum. Periphyses numerous near ostiole, ± simple, 15–24 × 1·5–2·0 μ. Paraphyses soon diffluxed and evanescent. Asci clavate, 60–65 × 18–21 μ, with colourless gelatinous wall up to 4(–5) μ thick. Spores 6–8, irregularly biseriate in ascus, elongate-ellipsoid, the ends rounded or sometimes bluntly pointed, thin-walled, 18–20 × 7·5–8·0 μ. With iodine, hymenial gelatine, and sometimes ascus walls also, pale rose-pink; contents of asci and spores yellowed.

This species apparently belongs to the very critical group of *V. aethiobola*.

Verrucaria maura Wahlenberg

apud Acharius, 1803, suppl. p. 19; Vainio, 1903, p. 38; Zschacke, 1934, p. 179.

Not present in our collections; the only antarctic record is that of Vainio, from west Graham Land: Palmer Archipelago, Moreno Island.

Geographical Distribution. A widespread species, occurring on the coasts of Europe, North America, Greenland, Iceland, Spitsbergen, Bear Island, Novaya Zemlya, Siberia, Bering Strait, Japan, and, in the southern hemisphere, Fuegia, Patagonia, South Chile, Falkland Islands[1] and New Zealand.

Verrucaria microspora Nylander (Fig. 3 *h*)

1855, p. 175; Zschacke, 1934, p. 195.
Verrucaria microspora f. *halophila* Nylander, 1855, p. 175.
Verrucaria halophila Nylander, apud Branth and Rostrup, 1869, p. 275.

West Graham Land. *Mainland Coast*: Cape Renard; on non-calcareous rocks at about normal high-tide level, constantly drenched by wave action during rough weather, together with *V. mucosa* Wbg.; F.I.D.S., 22. iii. 1944 (no. 1172 *pr. p.*). *Palmer Archipelago*: Port Lockroy, Goudier Islet; south side of islet on granodiorite rocks intermittently submerged by the tide; F.I.D.S., 23. iv. 1944 (no. 1220 *pr. p.*); east side of islet, on lower part of basalt dyke exposed only at low tide; F.I.D.S., 23. iv. 1944 (no. 1228).

South Orkneys. *Fredriksen Island*: on non-calcareous rock; Discovery 1931–3, 4. i. 1933 (nos. 1090–19, 1090–28).

Sporadic and scarce. F.I.D.S. no. 1228 is the typical form, with entirely colourless excipulum; the other specimens belong to the form *frisiaca* (Erichs.) Santesson, 1939, p. 41 (*V. frisiaca* Erichsen, 1930, p. 224), characterized by the somewhat pigmented, brownish excipular wall. Spores 8–12 × 4–5 μ.

Geographical Distribution. New to the Antarctic; widely distributed on the coasts of Europe, also recorded from North America (Maine), Greenland, Japan, and Chile.

[1] Collected by me at Port Louis, Berkeley Sound, in Feb. 1946.

Verrucaria mucosa Wahlenberg (Fig. 1*c*)

apud Acharius, 1803, suppl. p. 23; Zschacke, 1934, p. 192; Santesson, 1939, p. 4.

West Graham Land. *Mainland coast*: Cape Renard; on non-calcareous rocks at about normal high-tide level, constantly drenched by wave action during rough weather; F.I.D.S., 22. iii. 1944 (no. 1172 *pr. p.*).

Quite typical, although poorly developed. Thallus thin, in scattered irregular patches, continuous or with a few sporadic cracks probably due to post mortem drying. Spores 9–13 × 6–7 μ.

Geographical Distribution. New to the Antarctic. Occurs on the Atlantic seaboard of Europe, Iceland, Greenland, North America, Siberia; also in the subantarctic (Fuegia, Auckland Island, Campbell Island); possibly in New Zealand (Santesson, 1939, p. 17).

Verrucaria psychrophila M. Lamb, n.sp. (Fig. 3*g*; Pl. I, figs. 1, 3)

West Graham Land. *Palmer Archipelago*: Port Lockroy, Goudier Islet; on granodiorite rocks and boulders in the boat harbour and on the south side of the islet, intermittently submerged by the tide; F.I.D.S., 25. iii. 1944 (no. 1178, holotype); 21. iv. 1944 (no. 1219); 23. iv. 1944 (no. 1220).

Description. *Thallus epilithicus, olivaceo-nigricans aut nigricans, madefactus leviter gelatinosus, contiguus, late expansus, effusus, modice incrassatus* (0·20–0·25 *mm. crassus*), *laevigatus, vix nitidus, reticulato-rimosus vel plerumque grosse areolatus, areolis* 1·0–2·5 *mm. latis, irregulariter angulosis, planis vel levissime convexis, rimis acutis ad* 0·1 *mm. latis separatis; ad peripheriam tenuior, anguste pallidus* (*olivaceo-albidus*), *hypothallo nullo; stratum basale thalli haud fuliginosum. Gonidia laete vel flavidoviridia,* 8–15 (–20) *μ diam., in seriebus verticalibus disposita. Perithecia numerosa, in quavis areola* 2–20, *immersa, apice atro, haud vel paullum nitido, subconvexo,* 0·1–0·2 *mm. lato leviter emergenti; ostiolo nec papillato nec impresso, indistincto. Excipulum globosum aut depresso-globosum,* 165–180 *μ diam., omnino incoloratum, superne involucrello carbonaceo-fuligineo, lateribus leviter producto,* 20–40 *μ crasso,* 210–245 *μ lato obductum. Paraphyses mox dissolutae. Asci clavati,* 40–50 × 12–18 *μ, pariete aequaliter tenui. Sporae 8nae, in asco irregulariter biseriatim dispositae, simplices, incolores, ellipsoideae,* 11–13 (–15) × 6–7 *μ. Pycnidia numerosa, peritheciis intermixta, maculis punctiformibus atris circ.* 0·05 *mm. diam. indicata, haud prominentia; pycnoconidia bacillaria, recta aut rarius leviter curvata,* 3–4 × 0·6–0·7 *μ. Thallus extus intusque* KHO-, $CaCl_2O_2$-, $C_6H_4(NH_2)_2$-, I-; *gelatina hymenialis I+ leviter roseo-rubescens vel-, ascis sporisque lutescentibus, strato ascigero pallide caerulescenti.*

The thallus has a rudimentary brown or olive-brown cortex 7–12 μ deep, formed from the pigmented, concrete ends of the vertical thalline hyphae; the cells are thin-walled, 3·0–4·5 μ diam. The gonidial algae occupy the entire depth of the thallus, but are more concentrated and larger in the upper half; arranged in distinct vertical rows; bright green in living material, subglobose or irregularly angulose, often ± horizontally flattened, thin-walled, multiplying by fission into 2's, 4's and 8's. Fungal tissue between algae colourless, hyaline, compact, entirely paraplectenchymatic, with oblong, upright, or ± cubical thin-walled cells 3·0–4·5 × 2·5–3·0 μ. Excipulum colourless, of even thickness all round (18–30 μ), formed of tangentially elongated thin-walled cells. Involucrellum brown-black, slightly convex, about 20 μ thick round ostiole, 35–40 μ thick at margin. Periphyses crowded on upper inner wall of excipulum, simple, 12–30 × 1·5–2·5 μ. Spores thin-walled, often with granulose contents but no large guttules. Pycnidia globose or flask-shaped, 75–120 μ across, 100 (–300) μ deep, with colourless perifulcrium; ostiole surrounded by brown-black tissue like a small involucrellum. Fulcra exobasidial, subulate.

This species appears to be related to *V. ceuthocarpa*, from which it differs in the much larger thallus-areolae, extensive growth-habitus, and somewhat longer spores. From *V. tesselatula* Nyl. it is distinguished by the blackish, more regular areolae without darker edges. It is also ecologically distinct from

these two species, occurring at a low level in the littoral zone which would correspond in the Northern hemisphere to the *Fucus vesiculosus-Balanus* belt.

Owing to the pronounced irregularity of the tides at Port Lockroy (they are seasonal rather than diurnal) it is impossible to fix the position of the lichen in terms of 'high' or 'low' tide marks, and difficult to assess the relative degrees of submergence and exposure. A series of observations was made from 22 April to 24 May 1944; during this period exposure was noted only on 20, 21 and 22 May, for a few hours daily. Towards the end of May the boat harbour froze over for the winter, and on subsequent occasions, when the tide ebbed out sufficiently far to expose the lichen, the latter remained covered by the ice layer. By the beginning of July the ice covering it was up to 75 cm. thick. After the break up of the ice in late October a prolonged period of abnormally low spring tides set in, and the lichen was regularly exposed for several hours each day.

In the summer months *V. psychrophila* is most conspicuous on the boulders in the boat harbour of Goudier Islet, blackening them with what looks from a distance like a sooty coating (Pl. I, fig. 1). Seen from close quarters the colour is greenish blackish or olive-blackish (Ridgway, 1912, p. xlvii, 25''''*m*, pl. li, 23'''''*m*). It also occurs on the solid rock at the other (southern) side of the islet, at the same level. In its vertical distribution it is restricted to the hydrohaline and does not appear to overlap either the lower zone of the permanently submerged *V. serpuloides* or that of the upper spray-zone species (*V. ceuthocarpa*). The brown alga *Adenocystis utricularis* occurs at the extreme base of its vertical range.

Santesson (1939) has pointed out that the degree of cracking in the thallus of the marine *Verrucariae* is to some extent connected with the degree of submersion to which they are subject. The specimens of *V. psychrophila* which I collected from the south side of Goudier Islet (no. 1220) have a much less cracked thallus than those from the boat harbour; the cracks are more sporadic, not joining up to delimit distinct areolae. Although the vertical horizon is the same, it is possible that the lichen in this relatively exposed position is more constantly wetted by wave action.

As in several other marine *Verrucariae*, the thallus becomes brown after some time in the herbarium.

Verrucaria Racovitzae Vainio (Fig. 3*a*; Pl. IV, fig. 2)

1903, p. 38; Darbishire, 1923, p. 106.

Not present in our collections. It occurs in west Graham Land: Palmer Archipelago, Moreno Island (Vainio, loc. cit.), and also, *fide* Darbishire (loc. cit), on Elephant Island in the South Shetlands. I have not seen Darbishire's specimen.

The holotype specimen in herb. Vainio (Exped. Antarct. Belge, no. 196 *pr. p.*) is shown on Pl. IV, fig. 2. It is a small fragment of thallus about 1 cm. across, occurring together with *V. elaeoplaca* f. *glaucoplaca*, on fine-grained non-calcareous rock. Thallus 0·1–0·2 mm. thick between the perithecia, rimose or in places subcontinuous, the cracks (up to 0·1 mm. wide) occasionally reticulating to delimit irregularly angulose areolae 0·5–1·4 mm. diam.; olivaceous-glaucescent or buff-coloured, i.e. approximately the same colour as the thallus of *V. elaeoplaca*, not changing when moistened; surface smooth, matt, not pruinose. A black hypothallus is visible in cross section, underlying the thallus. Cortex present, pale brown or almost colourless, 9–14 μ deep, of $\pm$isodiametric, thin-walled cells 2–3 μ diam. The whole depth of the thallus above the basal carbonaceous layer is filled with gonidial algae, which are irregularly scattered, bright green, globose or angular, 8–11 μ diam., thin-walled. Fungal tissue between algae hyaline, paraplectenchymatic, of thin-walled cells 2–3 μ diam. Perithecia numerous, clothed by thallus almost to ostiole, forming hemispherical verrucae 0·7–0·9 mm. diam., with dark brown or blackish circular apex 0·2–0·3 mm. diam., slightly mamillate, with minute central pore. The thallus clothing the perithecia contains a thin layer of gonidia. Excipulum globose or upright-oval in

section, about 450 μ diam., with entirely brown-blackish wall 25–35 μ thick, and covered to the base by a massive carbonaceous involucrellum 75–100 μ thick which fuses with the hypothalline tissue below. Periphyses indistinct. No paraphyses. Asci clavate, 50–65 × 12–20 μ, with colourless gelatinous walls up to 5 μ thick. Spores 8, irregularly biseriate in ascus, with granulose contents and wall about 0·7 μ thick, ellipsoid or occasionally broadly ellipsoid, 15·0–16·5 × 9–11 μ. Pycnidia indicated externally by non-prominent, black, round or slightly elongated, ring-like spots about 0·15 mm. diam.; compound, consisting of several flattened intercommunicating chambers with colourless walls 6–9 μ thick; ostiole surrounded by carbonaceous tissue. Fulcra exobasidial, simple. Pycnoconidia bacillar, straight, 3·0–3·5 × about 0·7 μ.

Chemical reactions: surface of thallus and medulla KHO- (or brownish), $CaCl_2O_2$-, KHO($CaCl_2O_2$)-, $C_6H_4(NH_2)_2$-. Hymenial gelatine pale wine-red with iodine.

V. Racovitzae belongs to the section *Lithoicea* and appears to be related to *V. cataleptoides* Nyl.

Verrucaria serpuloides M. Lamb, n.sp. (Fig. 3*e*; Pl. I, fig. 2; Pl. II, fig. 1; Pl. IV, fig. 8)

West Graham Land. *Palmer Archipelago*: Port Lockroy, Goudier Islet; on granodiorite rocks west of the boat harbour, below the level of the lowest spring tides and therefore permanently submerged; F.I.D.S., 27. viii. 1944 (no. 1250 *pr. p.*); 19. x. 1944 (nos. 1321, 1322).

East Graham Land. *Trinity Peninsula, south coast*: Hope Bay; in rock pool just below low-water mark on occasion of low spring tides; F.I.D.S., 21. xi. 1945 (no. 2565, holotype).

Description. *Thallus epilithicus, piceo-niger (partibus tenuibus olivaceo-nigricans), effusus, uniformis, substratum late tegens, contiguus, ad 0·5 mm. crassus, ambitu tenuior et haud zonato-circumscriptus; continuus, laevigatus, subnitidus, statu madefacto sat gelatinosus, strato basali haud fuliginoso; gonidia laete viridia, globosa compressave, 6–10(–12) μ diam., seriebus verticalibus per totam crassitudinem thalli disposita. Perithecia sat numerosa, sparsa, thallo immersa, apice (involucrello) bene prominenti, tumido-annulari vel truncato-subconico, atro, saepe nitido, 0·30–0·45 mm. diam., superne primo planiusculo, demum concavo-impresso; poro centrali semper conspicuo, 0·03–0·06 mm. lato. Excipulum globosum, 300–435 μ diam., 30–45 μ crassum, basi lateribusque incoloratum, superne cum involucrello carbonaceo, 60–115 μ crasso, extrorsum haud producto confluens. Paraphyses nullae. Asci clavati aut ventricoso-clavati, membrana gelatinoso-incrassata, vix visibili, 3–7 μ crassa, cavitate plasmophora 40–50 × 12–18 μ. Sporae 6–8nae, in asco subbiseriatae, simplices, incolores, ellipsoideae vel late ellipsoideae, membrana sat tenui (ad 0·7 μ), (13–) 14·0–15·5 × 8–10 μ. Pycnidia sparsa, extus haud vel vix visibilia, omnino immersa, ostiolo haud carbonaceo; pycnoconidia bacillaria, recta, 5–7 × circ. 1·5 μ. Thallus extus intusque* KHO-, $CaCl_2O_2$-, $C_6H_4(NH_2)_2$-, I-; *gelatina hymenealis I+subtilissime rosea vel-, parietibus ascorum immutatis, sporis fulvescentibus.*

Thallus in section has a slightly developed light brown cortical layer up to 10 μ thick, formed from the end cells of the vertically fused thalline hyphae; cells thin-walled, 3–4 μ diam. Gonidial algae in well-marked vertical rows, larger and more crowded in upper 60–90 μ of thallus, often slightly horizontally flattened, multiplying apparently by binary fission. Medullary tissue hyaline, paraplectenchymatic, of ± cubical thin-walled cells 3–5 μ diam. No dark hypothalline tissue present. Excipulum formed of tangentially running compacted hyphae about 2 μ thick. Periphyses well developed on upper inner side of excipulum round the ostiole; embedded in hyaline mucilage, simple or sparingly branched, 30–45 × 1·5–2·5 μ. Asci spring from both base and sides of excipulum; the outlines of their swollen and highly gelatinized walls can be distinguished only after treatment with iodine, which tints the surrounding mucilage ± rose pink. The spores often contain a single moderate guttule. Pycnidia irregularly flask-shaped, about 60 μ across, 150 μ deep. Perifulcrium colourless. Fulcra exobasidial, simple, subulate, 12–20 × 1·5–2·0 μ.

Quite distinct from *V. mucosa*, the only species with which it may be said to have any affinity, by the much larger and prominent perithecia. It is of interest in being the only known marine lichen which passes its entire existence under water. *V. mucosa*, hitherto regarded as the most truly marine of all lichens, does not tolerate constant submersion; see in this connexion the remarks of Santesson (1939).

V. serpuloides occurs at the same level as an encrusting calcareous alga (*Lithophyllum* sp.?), and forms with it a submarine association just below the lowest ebb-tide level. During the exceptionally low spring tides at Port Lockroy on 2 and 3 November 1944, some of the uppermost patches of the calcareous alga-*Verrucaria serpuloides*-association were exposed for a short period[1], but at the most extreme ebb I could see the association running down on shelving rocks to a depth of several feet below the surface, where it is certainly never exposed (Pl. I, fig. 2). One also finds the association in rock pools left by the receding tide, both the calcareous alga and the *Verrucaria* consistently keeping below the water level. This is shown in the underwater photograph Pl. II, fig. 1, in which the *Verrucaria* is seen as a black band the upper edge of which coincides exactly with the surface of the water in the pool when the latter is left at ebb tide. This clear-cut upper limit is an indication that the submarine habitat in *V. serpuloides* is obligatory and not facultative.

Verrucaria tesselatula Nylander (Fig. 3*d*; Pl. IV, fig. 9)

apud Crombie, 1876, p. 191; Müller (Arg.), 1889, p. 172.
Verrucaria dermoplaca Nylander, apud Crombie, 1876*a*, p. 234 (vide infra).
Verrucaria glaucoplacoides Darbishire, 1912, p. 18, pl. 3, figs. 34, 35; Cengia Sambo, 1926, p. 23.

South Orkneys. *Inaccessible Islands*: on schistose rock (non-calcareous); Discovery 1931–3, 25. i. 1933 (nos. 1094–1, 1094–2).

Comparison of the holotype of Darbishire's *V. glaucoplacoides* from East Falkland with a syntype of Nylander's *V. tesselatula* from Kerguelen (in herb. Kew) showed them to be identical. This species is closely related to *V. ceuthocarpa*, from which it differs in the lighter coloured thallus with larger areolae separated by gaping black cracks. Darbishire's photographs (loc. cit) show the habitus well. The following data are derived from the syntype specimen from Swain's Bay, Kerguelen, coll. Transit of Venus Expedition, 1874–5.

Thallus 0·15–0·20 mm. thick, even, tesselate-areolate with plane, angulose areolae 0·5–1·0 mm. diam. separated by conspicuous black cracks about 0·15 mm. wide; matt, not pruinose, pale buff-brown. No basal fuliginous layer. Gonidial algae subglobose, 9–15 μ diam., with a slight tendency to form vertical rows in the thallus; $\pm$ bright green, multiplying by binary fission, so that two are often seen together in the same sheath, as mentioned by Nylander. Perithecia numerous, 1–6 in an areola, up to 0·2 mm. diam., with the black convex apex (involucrellum) rising slightly above thallus level, matt or slightly shining, not impressed or papillate, with very minute ostiole. Excipulum globose, immersed, 165–180 μ diam., with colourless wall. The involucrellum, brown-blackish in section, forms a dome-like roof over the upper part of the excipulum. No paraphyses. Asci clavate, about $40 \times 12\,\mu$, with indistinct gelatinized walls. Spores about $11 \times 7\,\mu$ ($10–15 \times 7–8\,\mu$ according to Nylander).

The specimens from East Falkland agree well with the Kerguelen type. The specimen from Tierra del Fuego, Ushuaia, coll. Dusén, distributed in 'Lichenes austroamericani ex Herbario Regnelliano', no. 377, and also one of the South Orkneys specimens (no. 1094–1) have in places more isolated and less reticulating cracks, leaving small areas of the thallus continuous and unbroken; they show the first stages of a transition into the extreme state in which the thallus is not areolate, but divided by a loose and irregular network of rhagadiose black-edged cracks into irregular islands of various size.

[1] The parts of the calcareous alga thus exposed subsequently died.

This state was described by Nylander on material from Fox Bay in West Falkland as '*Verrucaria dermoplaca*' and for practical purposes may be distinguished as *V. tesselatula* f. *dermoplaca* (Nyl.) M. Lamb, n.comb. The South Orkneys specimen no. 1094–2 belongs to this form.

Apart from these differences in external habitus, the variability of this species is not great. The thallus varies in colour from pale glaucescent buff (Ridgway, 1912, pl. xl, 19‴*b*) to a pinkish brown (pl. xlvi, 13⁗*i*), usually yellowish buff or brown-buff (pl. xl, 17‴*h*). Upper cortex present: brown, 9–15 μ deep, composed of ± rounded, thin-walled cells 3·0–4·5 μ diam. Fungal tissue between gonidial algae hyaline, paraplectenchymatic. Perithecia up to 0·25 mm. diam., varying on the same thallus from slightly convex-emergent to hemispherical. Excipulum variable in size, 165–270(–300) μ diam., always with hyaline wall at base and sides. Usually there is no trace of paraphyses, but occasionally a few isolated hyphae are present in the mucilage around the asci. Asci up to $50 \times 20\,\mu$, with diaphanous gelatinized walls up to 5 μ thick. Spores $11–15 \times 6·5–9·0\,\mu$. Hymenial gelatine rose-pink with iodine.

V. tesselatula, like the related *V. ceuthocarpa*, is a marine species of the spray zone. I saw it at Port Louis, East Falkland, forming extensive patches on shoreline rocks 0·5–1·0 m. above high-water level, associated with *V. maura*. The South Orkneys specimens occur together with *Caloplaca cirrochrooides* (Vain.) Zahlbr., which is also a species characteristic of the upper spray zone.

GEOGRAPHICAL DISTRIBUTION. Subantarctic-antarctic, perhaps circumpolar; Kerguelen, Falklands, Fuegia, South Orkneys.

Verrucaria sp.

SOUTH ORKNEYS. *Inaccessible Islands*: on schistose rock, together with *V. tesselatula* Nyl.; Discovery 1931–3, 25. i. 1933 (no. 1094–2 *pr. p.*).

A small patch of olive-blackish, rimose, minutely black-punctate thallus. Unfortunately, no mature perithecia are present. The thallus indicates that it belongs to the *antricola-aractina-Erichsenii-scotina-Zschackeana* group, none of which have as far as I know been recorded from the southern hemisphere.

EXCLUDED SPECIES

Verrucaria exquisita Darbishire, 1912, p. 17.

Re-examining the type material from South Georgia, I found it to be *Lecidea Dicksonii* (Gmel.) Ach. in a very poorly developed condition, with minute juvenile apothecia about 0·1 mm. in diameter, in their unexpanded state resembling perithecia. The upper part of the thecium was characteristically aeruginose, and two spores were seen, $10–12 \times 5–7\,\mu$.

Genus **Thelidium** Massalongo, 1855

Three species attributed to this genus were found in Marie Byrd Land by the second Byrd Antarctic Expedition, and described by Dodge and Baker (1938). One of them, *Th. Caloplacae* Dodge and Baker, is a lichen-parasite with numerous spores in the ascus, and should hence be excluded from the genus. The others, *Th. inaequale* Dodge and Baker, p. 524, pl. 38, figs. 1–5, and *Th. parvum* Dodge and Baker, p. 526, pl. 62, figs. 393–395, the first occurring on schistose rocks and the second over the thallus of a *Parmelia* on sandy loam, show some spore characters unusual in this genus. In *Thelidium inaequale* the spores are dark coloured, 1-septate with frequently unequal cells, $10–13 \times 5–7\,\mu$; in *Th. parvum* colourless, 1-septate with unequal cells, $7·5–9·0 \times 3·0–3·5\,\mu$. The thallus in both these species is extremely reduced or evanescent, and the perithecia are of simple structure with entire dark walls of only a few cell layers in thickness.

Genus Staurothele Norman

1853, p. 240.

Staurothele gelida (Hook. f. and Tayl.) M. Lamb, n.comb. (Fig. 3*j*, *k*)

Verrucaria gelida Hooker and Taylor, 1844, p. 639.

'*Verrucaria umbrina*' in Hooker, 1845–7, p. 541, pl. cxcviii, fig. iv (non Wahlenberg).

Verrucaria umbrina var. *monospora* Nylander, 1855, p. 175.

Verrucaria monospora Malme, 1928, p. 9.

West Graham Land. *Palmer Archipelago*: Port Lockroy, Goudier Islet; near summit of islet, altitude *c.* 7 m., on vertical south-facing side of basalt dyke; F.I.D.S., 28. xii. 1944 (no. 2125); near summit of islet, on old limpet shells; F.I.D.S., 28. xii. 1944 (no. 2101). *Argentine and neighbouring Islands*: Berthelot Islands; on north-facing inland cliff (non-calcareous); B.G.L.E., 18. iii. 1935 (nos. 1081–32, 1094–91).

East Graham Land. *Crown Prince Gustav Channel*: Station 30; west side of island, on agglomerate rocks in slope just above sea-level; F.I.D.S., 12. xi. 1945 (no. 2841 *pr. p.*). Corry Island[1]; on agglomerate outcrop near sea-level at foot of scree slope; F.I.D.S., 17. xi. 1945 (no. 2835 *pr. p.*). Persson Island; north-west shore, at sea-level, on non-calcareous stones; F.I.D.S., 21. xii. 1945 (nos. 2663, 2664). *James Ross Island*: St. 51; altitude *c.* 60 m., on basaltic stones irrigated in summer by snowmelt water; F.I.D.S., 23. xi. 1945 (nos. 2640, 2641 *pr. p.*, 2642 *pr. p.*). Cape Lachmann; altitude *c.* 30 m., on non-calcareous stones near a fresh-water pond; F.I.D.S., 21. xi. 1945 (no. 2673); altitude *c.* 60 m., on basaltic rock; F.I.D.S., 21. xi. 1945 (no. 2781). *Seymour Island*: western slopes of plateau in north part of island, altitude *c.* 150 m., on a calcareous stone; F.I.D.S., 30. viii. 1945 (no. 2477 *pr. p.*).

Like *St. clopima* (Wbg.) Th. Fr., but spores constantly single in ascus and usually larger than in *St. clopima*: $(45–)60–75 \times (15–)21–32\,\mu$ (or up to $90\,\mu$ long, in Argentine specimens according to Malme, loc. cit.).

The holotype of '*Verrucaria gelida*' from Cockburn Island in the Erebus and Terror Gulf was located in the herbarium of Churchill Babington, now in the British Museum. In outward appearance it is quite similar to *Staurothele clopima*, and like that species has bacilliform hymenial gonidia. Single-spored asci are occasionally met with in *St. clopima*, but the uniformity of the character in all our Antarctic material seems to justify the specific separation suggested by Malme.

In external morphology the range of variation is like that of *St. clopima*, that is to say, large. The thallus may be reduced and scanty, consisting of a thin crust between the perithecial warts (as in the Cockburn Island holotype) or up to 1 mm. thick and verrucose-areolate. In the former case a ring of gonidia-bearing thallus tissue is often carried up and isolated on the sides of the perithecium (Fig. 1*j*). The colour of the thallus varies with exposure, from a medium brown (Ridgway, 1912, pl. xlvi, 13''''*k*) in shaded south-facing positions, to brown-black (Ridgway, pl. xlvi, 17''''*n*) in some cases on exposed stones (no. 2673). The excipulum is more or less globose, variable in size ($200–300\,\mu$ diam.), colourless or almost so when young, but becoming increasingly brown with age, until, in old perithecia, it consists entirely of dark brown tissue hardly distinguishable from the apical brown-blackish involucrellum. The hymenial gonidia are cubical to bacillar, $3–9 \times 2{\cdot}5–3{\cdot}0\,\mu$, pale green. Thalline gonidia bright green, $\pm$globose, thin-walled, $6{\cdot}0–10{\cdot}5\,\mu$ diam.

Hooker's illustration in the *Flora Antarctica* shows the single spores still enclosed in the ascus.

Like *St. clopima*, *St. gelida* is particularly characteristic of positions seasonally inundated by fresh-water rivulets, in this case derived from the melting of snow and ice. One finds it on lowlying ground with good snow cover throughout the winter, and where during the heavy thaws of spring and early summer it leads a purely aquatic existence. Its maximal development was seen on James Ross Island

[1] Formerly Cape Corry.

(no. 2640), where it formed a conspicuous association on flat stones lying in extensive rivulets and seepage areas derived from an ice cap higher up.

Geographical Distribution. Outside the Graham Land sector of the Antarctic, this species is known from Argentina and Chile. It and *St. clopima* are perhaps bipolar-vicarious species.

Genus Microglaena Körber, 1855

Microglaena antarctica M. Lamb, n.sp. (Fig. 3*p*; Pl. IV, fig. 5)

South Shetlands. *Nelson Island*: Harmony Cove, on fine-grained non-calcareous rock; Discovery 1933–5, 14. xii. 1934 (nos. 1480–1, 1480–2, the latter the holotype). *Deception Island*: east coast, by Ringed Penguin rookery, on agglomerate rock; B.G.L.E., 16. i. 1936 (no. 1381–3); tuff cliffs above main Ringed Penguin rookery, altitude *c.* 140 m.; B.G.L.E., 20. i. 1936 (nos. 1399–4, 1400–13, 1400–38); south-west side of 'Neptune's Bellows', on weathered agglomerate crags with fair shelter; Discovery 1933–5, 10. i. 1935 (nos. 1488–1, 1488–2 *pr. p.*). *Desolation Island*: on non-calcareous rocks in gull rookery, altitude *c.* 20 m.; Discovery 1933–5, 8. i. 1935 (no. 1487–6).

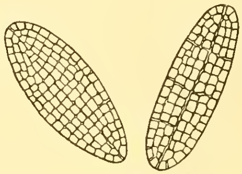

Fig. 4. *Microglaena antarctica* M. Lamb. Spores.

Description. *Thallus crustaceus, uniformis, plagulas irregulares 0·4–2·5 centim. latas inter alios lichenes formans, primo areolatus, mox verrucoso-areolatus aut congeste verrucosus, ad* 1 (–2) *mm. crassus, albidus vel impure albidus vel sordide eburneus, opacus, epruinosus; areolae seu verrucae* 0·3–1·0 *mm. diam., rotundatae angulosaeve, planae aut convexae, saepe convoluto-tuberculatae. Hypothallus nullus distinctus; soredia et isidia desunt. Gonidia cystococcoidea, globosa,* 4·5–15·0 μ *diam., pallide aut sat laete viridia, pariete tenui. Perithecia singulatim verrucis thallinis* 0·5–1·0 *mm. latis insidentia, thallo obducta, apice denudato fusconigricanti, ostiolo punctiformi, minuto, saepe leviter papillato. Excipulum immersum, globosum,* 450–520 μ *diam., omnino incoloratum, superne involucrello fusconigricanti, lateribus haud vel parum producto obtectum. Paraphyses persistentes, filiformes, haud ramoso-connexae,* 1·0–1·5 μ *crassae, sinuosae, in aqua facile separandae. Asci clavati,* 135–210 × 30–40 μ, *pariete incolorato* 3·0–7·5 μ *crasso. Sporae* 4–7(*rarius* 8)*nae in asco, uni- aut partim biseriatim dispositae, oblongo-ellipsoideae aut ellipsoideo-fusiformae, muriformi-cellulosae* (*cellulis numerosis cuboideis*), *incoloratae vel levissime infuscatae, halone nullo indutae, formam magnitudinemque haud paullum variantes,* 42–90 × 13–35 μ, *plerumque circ.* 60 × 25 μ. *Pycnidia verrucis thallinis immersa, ostiolo nigricanti punctiformi* 0·1–0·3 *mm. diam.; pycnoconidia filiformia, curvata rectave,* 15–24 × 0·6–0·8 μ. *Thallus extus et intus* KHO- *vel sordide flavofuscescens,* $CaCl_2O_2$-, $C_6H_4(NH_2)_2$-, I-; *sporae plasmaque ascorum I+rubrofulvescentes.*

There is no basal hypothalline layer, the thallus being attached to the substratum by the hyphae of the lower medulla. Thallus corticate; cortex colourless, 15–34 μ thick, of ±rounded, thin-walled cells 2·5–5·0 μ diam., in places crushed and indistinct. Gonidial stratum 60–250 μ deep, sometimes entirely filling the verrucose areolae; the algae in the lower parts of the thallus are often dead and brown. Medulla colourless, hyaline, composed of much branched and intricated hyphae 1·5–3·0 μ thick. The brown-black apex (involucrellum) of the perithecia is 0·2–0·5 mm. diam., matt or shining, with central, often lighter coloured ostiole. Excipulum colourless or with a faint yellowish tinge, formed of compacted tangentially running hyphae about 1 μ thick. Involucrellum consists of dark-walled cells 3–5 μ diam., merging ±gradually into the surrounding colourless tissue. No hymenial gonidia. Paraphyses about the same length as the asci, not capitate; septa visible after treatment with KHO, HCl and I, 9–18 μ apart. Walls of asci not laminated, I-, with a thinner spot at the apex. Pycnidial fulcra exobasidial, simple, 9–13 × 1·0–1·5 μ.

Perhaps related to *M. subluridella* (Vain.) Zahlbr. (Brazil), but differing in the much thicker, verrucose, lighter coloured thallus, larger fertile verrucae, and larger spores. From the f. *terrestris* (Hue) Zahlbr. of *M. muscorum* (Fr.) Th. Fr. it is distinguished by the thicker thallus, colourless excipulum, number of spores in the ascus, and saxicolous habitat.

M. antarctica grows in small patches among other crustaceous lichens (*Caloplaca*, *Buellia*, etc.), and appears to be a rather ornithocoprophilous species.

Family DERMATOCARPACEAE

Genus **Dermatocarpon** Eschweiler, 1824

Section **Endopyrenium** Stizenberger

Dermatocarpon lachneum (Acharius) A. L. Smith (Fig. 3*n*)

1911, p. 270, pl. 37; Vainio, 1921, p. 18; Lynge, 1928, p. 37.
Lichen lachneus Acharius, 1798, p. 140.
Dermatocarpon hepaticum var. *lachneum* Zahlbruckner, 1921, p. 217; Zschacke, 1934, p. 605.
Endocarpon rufescens Acharius, 1810, p. 304.
Dermatocarpon rufescens Th. Fr., 1861, p. 354; Zschacke, 1934, p. 602.

East Graham Land. *Crown Prince Gustav Channel*: St. 28; west side of island, altitude *c.* 25 m., on sandy detritus on ledges in agglomerate cliffs; F.I.D.S., 16. xi. 1945 (no. 2792). St. 29; summit plateau of island, altitude *c.* 130 m., on detritus between rocks and stones; F.I.D.S., 13. xi. 1945 (no. 2828).

The reddish brown squamules are 2–8 mm. across, becoming at maturity contiguous and variously lobate, slightly concave and with conspicuously raised margins, which are for the most part eroded and grey-whitish where the tissue has been killed off by exposure. Most of the black spots on the upper surface are pycnidia, but a few perithecia are present; immersed, pyriform, up to 225 μ across and 360 μ deep, with faintly pink excipular wall. Involucrellum almost obsolete, dome-shaped, dark brown in section, merging at the sides into the thalline cortex. No paraphyses. Asci cylindrical, with bluntly pointed ends, $80–115 \times 9–15\,\mu$, with gelatinous wall about 3 μ thick, becoming thinner at maturity. Spores 8, uniseriate in ascus, ellipsoid, $13{\cdot}5–18{\cdot}0 \times 6{\cdot}0–8{\cdot}5\,\mu$. Mucilage of hymenium faintly pink with iodine. Pycnidia immersed, globose, up to 330(–480) μ diam., without distinct wall, filled with spongy canaliculate sporogenous tissue consisting of the massed endobasidial fulcra; pycnoconidia bacillar, $4 \times 1\,\mu$.

One of the few lichens which were present on the bleak summit plateau of St. 29, where there can be no protecting snow cover during the winter on account of the completely exposed situation. It is hardly surprising, therefore, to find necrosis of the raised margins of the squamules, due probably to the eroding action of wind-blown powder snow, which can act like a sandblast in these regions.

Geographical Distribution. New to the Antarctic. A widely distributed species in the northern hemisphere, where it has a very broad range of latitude: North Africa, the Ukraine, southern, central and northern Europe, Iceland, North America from New Mexico to New England, and the Arctic (Greenland, Spitsbergen, and Novaya Zemlya). It has also been recorded from northern India. I do not know of any previous record from the southern hemisphere, but the closely related *D. hepaticum* has been recorded from Western Australia and New Zealand by Müller Arg., and it is possible that some of the material may refer to the present species.

Section **Entosthelia** (Wallroth) Stizenberger

Dermatocarpon intestiniforme (Körber) Hasse (Fig. 10)

1912, p. 46.
Endocarpon intestiniforme Körber, 1859–65, p. 42.
Dermatocarpon fluviatile var. *decipiens* f. *intestiniformis* Vainio, 1921, p. 13.
'*Lichen polyphyllus*' in Wulfen, 1788, p. 142 (non Linnaeus).
Dermatocarpon polyphyllum Dalla Torre and Sarnthein, 1902, p. 504; Zschacke, 1934, p. 627; Magnusson, 1934, p. 458; Lynge, 1938, p. 33.

East Graham Land. *James Ross Island*: The Naze; altitude *c.* 20 m., in a damp shaded overhung crevice in side of agglomerate rock, north-west exposure; F.I.D.S., 26. xi. 1945 (no. 2784).

About 30 thalli, varying in size from 1 to 3 cm. in diameter, were present in the hollow of the rock. They are of the polyphyllous-complicate type, with the lobes mostly convex with downrolled edges. Upper side dull brown, but for the most part covered with a fine caesious-whitish pruina; under side yellowish flesh-coloured to brown, $\pm$ wrinkled but not distinctly veined. The thallus does not become green when wetted. Nearly all the individuals were fertile, but spores were rather sparingly developed, $10{\cdot}5$–$12{\cdot}0 \times 5{\cdot}0$–$7{\cdot}5\,\mu$, averaging $11{\cdot}5 \times 6{\cdot}3\,\mu$.

This species and *D. miniatum* (L.) Mann (var. *complicatum* (Lightf.) Hellb.) are very similar and rather difficult to separate on morphological features. The chief difference is supposed to lie in the spores, which in *D. miniatum* are somewhat longer, 8–14 μ, or even up to 20 μ, according to Lynge (1938, p. 34). The average length/breadth coefficient is about 1·5 in *D. intestiniforme* and 2·0 in *D. miniatum* (Lamb, 1940, p. 267). In the exsiccat Körber, Lich. sel. German. no. 397, which is authentic material of *D. intestiniforme*, I found spores $8{\cdot}5$–$10{\cdot}5 \times 5{\cdot}0$–$6{\cdot}5\,\mu$ with an average length/breadth coefficient of 1·6–1·7. In the Antarctic material the coefficient works out at 1·8. Apparently therefore the difference in spore shape is not a very constant or reliable character, as in both species it fluctuates within rather wide limits. *D. intestiniforme* has a rather typical growth form, implied in the name, and noted by Santesson (apud Lynge, 1938, p. 34); the edges of the lobes are mostly rolled downwards: 'sehr auffallend sind die darmförmig verschlungenen, zur convexen Areolenform eingerollten mittleren Lappen,doch auch im Umfange ist der Thallus bei aller Verflachung wenigstens an den Rändern meist noch eingerollt' (Körber, loc. cit.).

The specific epithet *polyphyllum* (Wulfen) cannot be used for this species, because Wulfen (loc. cit.) refers to *Lichen polyphyllus* Linn., which is *Umbilicaria polyphylla* (L.) Hoffm.

Geographical Distribution. A bipolar species, new to the southern hemisphere; it occurs in central Europe (where it is alpine), Scandinavia, Iceland and the Arctic (Spitsbergen, Novaya Zemlya, Greenland, Arctic Canada). Lynge (1938, p. 33) has found *Dermatocarpon intestiniforme* to be a more northern species than *D. miniatum*, which it almost replaces in the Arctic. It has also been recorded from U.S.A.: Arizona and California.

Darbishire, 1910, p. 9, recorded an unnamed species of the genus *Endocarpon* from South Victoria Land: McMurdo Sound, Granite Harbour, collected by the British National Antarctic Expedition of 1901–4. The rock specimen referred to is preserved at the British Museum (Natural History), but no Pyrenocarp lichen appears to be now present on it.

Family MASTODIACEAE

Genus Mastodia Hooker f. and Harvey, 1847

Mastodia tesselata (Hooker f. and Harvey) Hooker f. and Harvey (Fig. 3 *m*; Pl. III, fig. 1; Pl. IV, fig. 1)

apud Hooker, 1847, p. 499, pl. cxciv, fig. ii; Vainio, 1903, p. 36, pl. iv, figs. 33, 34, 1909, p. 156; Hue, 1909, p. 315, figs. 1–5, 1915, p. 13; Darbishire, 1912, p. 41, pl. 3, fig. 36.

Ulvella tesselata Hooker f. and Harvey, 1845, p. 297.

Prasiola tesselata Kützing, 1849, p. 473; Hariot, 1889, p. 29, pl. 2, figs. 1–6; Knebel, 1936, p. 45.

Leptogiopsis complicatula Nylander, 1884, p. 211.

Laestadia prasiolae Winter, 1887, p. 16 (fungus).

Guignardia prasiolae Reed, 1902, p. 150 (fungus).

Dermatomeris Georgica Reinsch, 1890, p. 425.

South Shetlands. *King George Island*: Admiralty Bay, Martel Inlet; on fine-grained non-calcareous rock; Discovery 1933–5, 18. xii. 1934 (no. 1481–15); Esther Harbour, east side, slightly above sea-level; Discovery 1935–7, 6. i. 1937 (no. 1949–3). *Deception Island*: north side of crater to west of the whaling settlement, altitude *c.* 60 m., on andesitic stones on scree slope; F.I.D.S., 8. ii. 1945 (no. 2318 *pr. p.*). *Clarence Island*: Cape Bowles; Discovery 1935–7, 13. xi. 1936 (no. 1874–4).

West Graham Land. *Palmer Archipelago*: Port Lockroy, Goudier Islet; near summit of islet, altitude *c.* 7 m., on granodiorite rocks; F.I.D.S., 29. ii. 1944 (no. 1151), 28. xi. 1944 (no. 1833), 14. i. 1945 (no. 2234 *pr. p.*), 18. i. 1945 (no. 2256 *pr. p.*); on weathered wooden deck of old whaling scow on beach; F.I.D.S., 1. iv. 1944 (no. 1214). *Mainland coast between Cape Renard and Cape Bellue*: opposite Berthelot Islands; at foot of cliffs, on granitic rock; B.G.L.E., 27. vii. 1935 (no. 1188–1). *Argentine and neighbouring Islands*: Berthelot Islands; on north-facing granitic low sea cliff, altitude 5 m.; B.G.L.E., 18. iii. 1935 (nos. 1094–34, 1094–45). Galindez Island; on non-calcareous rock; B.G.L.E., 23. xi. 1935 (no. 1263–2). *Trinity Peninsula, north coast*: Cape Roquemaurel; on north-east-facing non-calcareous rocks, altitude 16 m.; Discovery 1933–5, 20. i. 1935 (no. 1490–2).

East Graham Land. *Trinity Peninsula, south coast*: Hope Bay; near Boeckella Lake, altitude *c.* 60 m., on non-calcareous rocks and stones; F.I.D.S., 15. iv. 1945 (nos. 2366, 2368 *pr. p.*, 2369 *pr. p.*, 2372 *pr. p.*); on stones at side of frozen shallow freshwater pool in the penguin rookery; F.I.D.S., 15. iv. 1945 (no. 2363 *pr. p.*).

This organism has been classified by different authors as a lichen, an alga, and a fungus. The algal component is *Prasiola crispa*.

It is the commonest Pyrenocarp lichen in the Graham Land sector of the Antarctic. Skottsberg (1912) has observed its transition into the free-living *Prasiola crispa*, and I saw this also on Goudier Islet. One of the features which speaks most strongly in favour of *Mastodia* being a true lichen is the vigour of the dual organism, and in particular its ability to withstand desiccation better than the free-living *Prasiola*. On Goudier Islet *Mastodia tesselata* covers large areas of the exposed smooth granodiorite rocks, an arid habitat throughout the whole of the summer, except for an occasional light fall of snow or sleet; the plants are nearly always completely dry and brittle to the touch. *Prasiola crispa*, on the other hand, although it can become desiccated for short periods without injury, is much more dependent on a supply of fresh water, and for this reason occurs only in hollows and crevices in the rocks where water tends to flow or accumulate.

Both *Mastodia* and *Prasiola* are highly nitrophilous, occurring in rookeries or on bird-rocks where an abundant supply of nitrogenous matter is available from bird excrement dissolved in snowmelt water. *P. crispa* is one of the most nitrophilous plants known, occurring even around the nests in

penguin rookeries. *Mastodia* avoids such extremely nitrogenous positions. In rock gutters, where a trickle of strongly ammoniacal drainage seeps over periodically from a source higher up, its passage is often intercepted first by a mat of the *Prasiola*, which apparently filters out the most highly concentrated constituents, solid matter, feathers, etc.; the *Mastodia*, often grading into the *Prasiola*, occurs on the side away from the source, thus encountering clearer and presumably less nitrogenous drainage water.

Associated species are *Caloplaca elegans*, *Xanthoria lychnea* (often epiphytic on the *Mastodia*), *Buellia* spp., *Lecania* (*Thamnolecania*) *Brialmontii* and *Verrucaria elaeoplaca*. The latter species is more hydrophilous, replacing *Mastodia* in the central portions of seepage channels (Pl. III, fig. 1).

M. tesselata has a preference for the harder types of rock (granodiorite, andesite, etc.). On Goudier Islet I noticed that it avoided certain fine-grained patches, of acid composition, in the granodiorite. An abnormal habitat was the weathered wooden deck of an old whaling scow which had lain on the beach for many years.

Geographical Distribution. Bipolar. In the northern hemisphere it occurs in eastern arctic Siberia (Pitlekai, Behring Straits), and is apparently altogether absent from the western Arctic; in the southern hemisphere, Kerguelen, South Georgia, Graham Land and adjacent islands, and Fuegia. The following is a list of the antarctic localities from which it has previously been recorded:

South Shetlands. *Nelson Island* (Darbishire, 1912).

West Graham Land. *Trinity Peninsula, north coast*: Astrolabe Island and small islet off the coast (Darbishire, 1912). *Palmer Archipelago*: Port Lockroy, Goudier Islet (Hue, 1915); Bob Islet off Wiencke Island (Vainio, 1903). *Mainland coast between Cape Charles and Cape Renard*: Cape Van Beneden (Vainio, 1903). *Kaiser Wilhelm II Archipelago*: Booth Island (Hue, 1909); Hovgaard Island (Hue, 1915).

East Graham Land. *Erebus and Terror Gulf*: Paulet Island (Darbishire, 1912). *James Ross Island*: west side, about lat. 64° (Darbishire, 1912).

[South Georgia. Royal Bay (Reinsch, 1890); Maiviken (May Harbour) (Darbishire, 1912).]

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PLATE I

Fig. 1. Part of the boat harbour, Goudier Islet, Port Lockroy, seen at low tide, showing blackish staining of the rocks caused by *Verrucaria psychrophila* M. Lamb. Phot. I.M.L., 23. iv. 1944.

Fig. 2. *Verrucaria serpuloides* M. Lamb, forming black patches on submerged granodiorite rocks off the shore of Goudier Islet, Port Lockroy, below the lowest ebb-tide level. (Under-water photograph.) Phot. I.M.L., 19. x. 1944.

Fig. 3. Close-up view of *Verrucaria psychrophila* M. Lamb, on a boulder in the boat harbour of Goudier Islet, Port Lockroy, at low tide. Phot. I.M.L., 4. xii. 1944.

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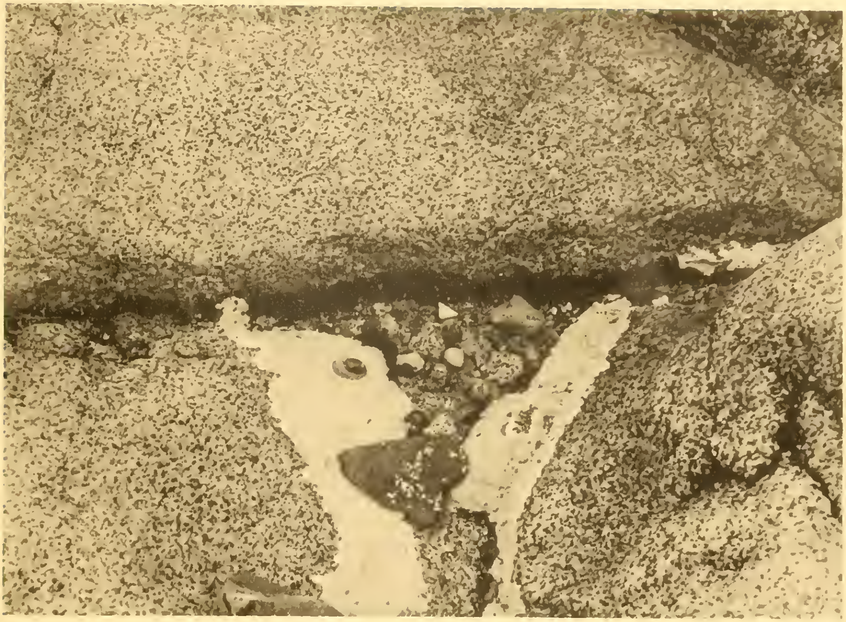
PLATE II

Fig. 1. *Verrucaria serpuloides* M. Lamb, associated with an encrusting calcareous alga (*Lithophyllum* sp.?) in a rock pool, Goudier Islet, Port Lockroy. The *Verrucaria* is seen as a dark band, the upper edge of which marks the level of lowest ebb tide. (Under-water photograph.) Phot. I.M.L., 26. x. 1944.

Fig. 2. Part of an extensive patch of *Verrucaria elaeoplaca* Vain., on a natural gutter in the granodiorite rocks of Goudier Islet, Port Lockroy, periodically moistened by a flow of snowmelt water. $\frac{1}{2}$ nat. size. Phot. I.M.L., 20. xii. 1944.



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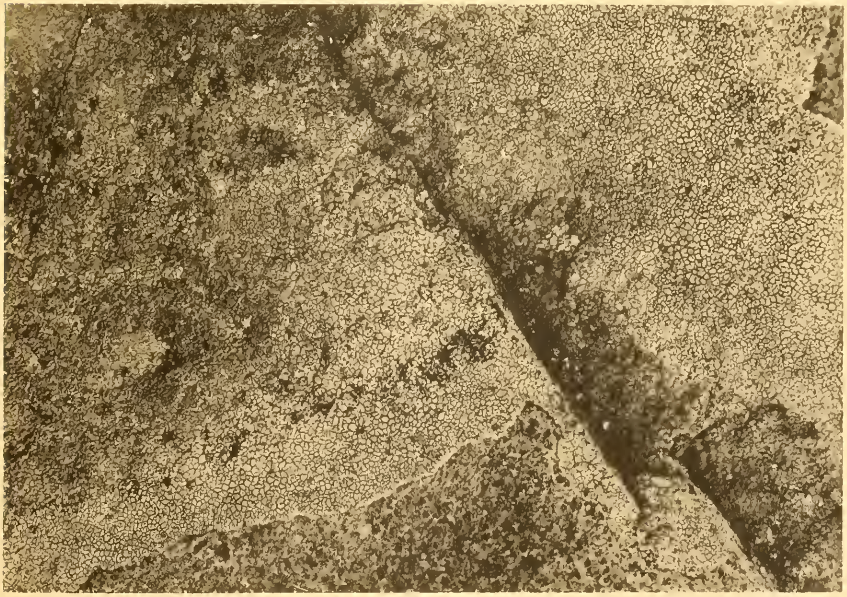

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PLATE III

Fig. 1. A natural gutter in the granodiorite rocks of Goudier Islet, Port Lockroy, showing growth of *Verrucaria elaeoplaca* Vain. and *Mastodia tesselata* Hook. f. and Harv. Photo. I.M.L., 3. i. 1945.

Fig. 2. A small snowmelt water pool in a hollow of the granodiorite rocks of Goudier Islet, Port Lockroy, with the water level bounded by a zone of *Verrucaria elaeoplaca* Vain. The *Verrucaria* is also seen lining the natural gutter which serves as a run-off from the pool. Phot. I.M.L., 3. i. 1945.

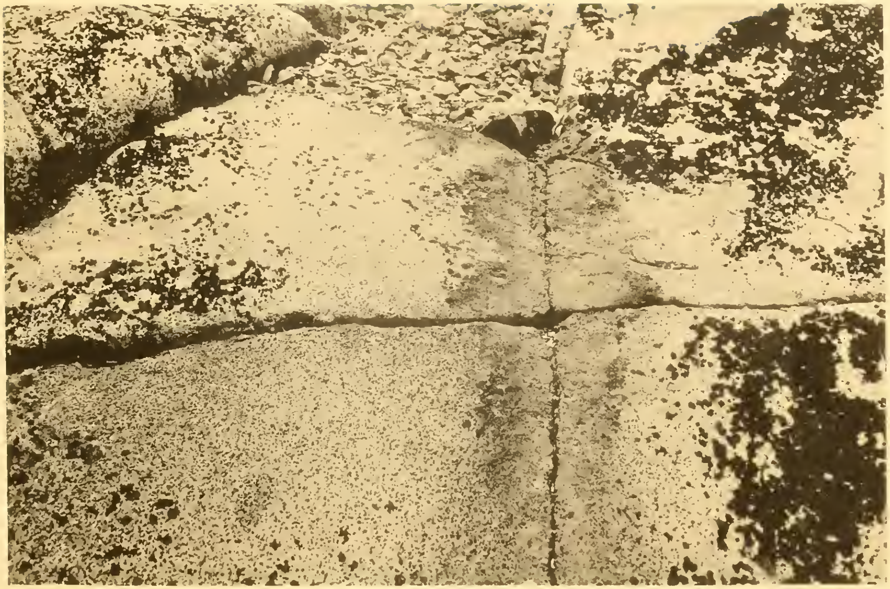

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PLATE IV

Fig. 1. *Mastodia tesselata* Hook. f. and Harv. growing on the ± vertical north-facing side of a bird-frequented granodiorite rock on Goudier Islet, Port Lockroy. Above are seen stages in the transition into the free-living alga *Prasiola crispa*, which replaces the *Mastodia* on the zenith surface of the rock. Also present: *Caloplaca elegans* Th. Fr. $\frac{1}{4}$ nat. size. Phot. I.M.L., 20. xii. 1944.

Fig. 2. *Verrucaria Racovitzae* Vain.; holotype specimen (above). The lower, coarsely rimose thallus is *Verrucaria elaeoplaca* f. *glaucoplaca* (Vain.) M. Lamb. × 4.

Fig. 3. *Verrucaria famelica* Darbish.; syntype specimen in herb. Kew. × 4.

Fig. 4. *Verrucaria cylindrophora* Vain.; part of the holotype specimen. × 4.

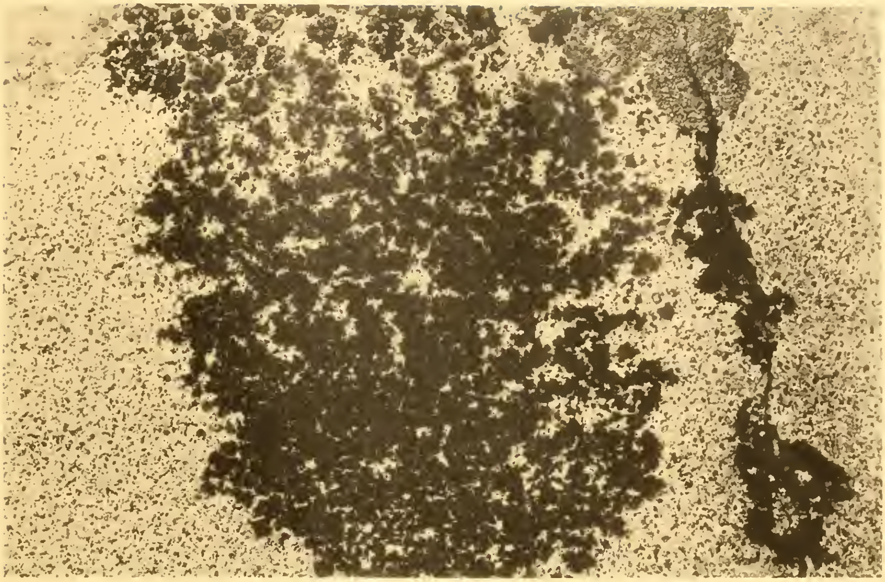
Fig. 5. *Microglaena antarctica* M. Lamb; part of the holotype specimen. × 4.

Fig. 6. *Verrucaria dispartita* Vain.; part of the holotype specimen. × 4.

Fig. 7. *Verrucaria psychrophila* M. Lamb; part of the holotype specimen. × 4.

Fig. 8. *Verrucaria serpuloides* M. Lamb; part of the holotype specimen. × 4.

Fig. 9. *Verrucaria tesselatula* f. *dermoplaca* (Nyl.) M. Lamb; part of syntype specimen in herb. Kew. × 4.



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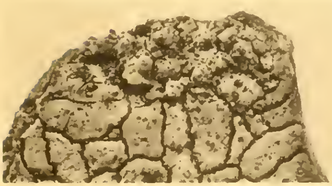

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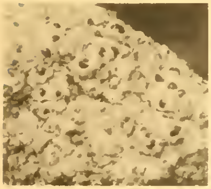

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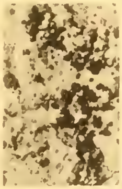

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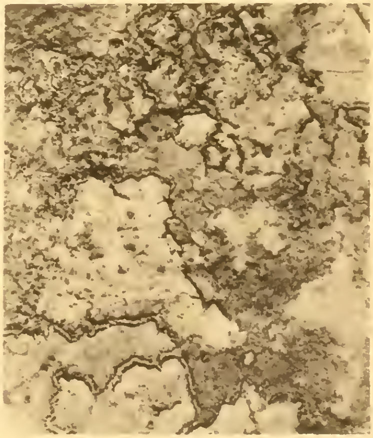


9

WHALE MARKING II

DISTRIBUTION OF BLUE, FIN AND HUMPBACK WHALES MARKED FROM 1932 TO 1938

By George W. Rayner

(Plates V–XXII; Text-fig. 1)

The progress and results of whale marking up to December 1939 have been described in a previous report[1] wherein is recorded the number of whales effectively marked and the details of the 203 marks then recovered. It was shown from this evidence that the striking feature of whale migration was the manner in which whales of all the three species concerned were found year after year in the same region of the Antarctic as that in which they were marked. This was quite rigidly so in the case of Humpbacks and to a lesser degree with Blue and Fin whales, which are occasionally to be found at more considerable distances from the positions where they were marked. It was also for the first time proved by direct evidence that Humpback whales move from the Antarctic to tropical waters in very definite migrations.

Whaling has only continued on a very subdued scale during most of the war years, but additional marks have been recovered since 1939, all corroborating the results arrived at up to that time. In the case of Fin whales we now possess marks recovered at every yearly interval up to thirteen, and in no instance is the distance between the position of marking and the position of recovery greater than already recorded in the above-mentioned report, which dealt only with marks recovered up to periods of four years. Now that whaling in the Antarctic has recommenced on a considerable scale a greater number of recoveries may be expected in the near future, but until this accrues it is felt that the time has not yet come for a fresh analysis of the data. In the meantime since the previous report gave no more than a rough indication of the distribution of marking (Plate XLV) it is considered useful to publish a detailed record of the positions of markings. These fuller details will substantiate the data already published, and perhaps clarify some of the conclusions reached. The positions of marking show, for instance, the importance of negative results. If whales are marked in various regions over a series of years a certain proportion of recoveries may be expected, and it would be of considerable significance if no marks (or exceptionally few) were recovered from whales marked in substantial numbers in some definite region on a particular occasion. In the same connexion the division of Humpbacks into stocks off Enderby Land and off Queen Mary Land can be considered established; if it were otherwise it is reasonable to conclude, in view of the number of markings off Enderby Land, that whales from both regions would have been taken off North-west Australia.

It is not proposed to draw any new conclusions in this paper, which is intended simply to record positions of marking; but studied in conjunction with the report of 1940 it will be of assistance to those interested in the distribution and migrations of whales.

The positions of marking are now set out in a series of monthly plottings dealing with each of the three important species (Plates V to XXII). Two charts drawn on a polar equidistant projection cover the region from 90° W to 120° E in which whale marking has been carried out (see Text-fig. 1). These charts have been divided into quadrilateral areas bounded by one degree of longitude and thirty minutes of

[1] Rayner, G. W., 1940, *Whale Marking, Progress and Results to December 1939*, Discovery Rep., XIX, pp. 245–84.

latitude, and it is upon these units of area that the plotting of distribution is based. These areas decrease in size towards the south, and as the projection is not an equal area representation the actual areas of the quadrangles are not strictly comparable, but may be taken as nearly so. One of the unit areas comprises in latitude 55° S, approximately 1034 square miles, in latitude 60° S, 900 square miles, and in latitude 65° S, 762 square miles. The number of whales marked in each area is represented by symbols, a solid circle indicating ten whales and an open circle one to nine whales. The full number of whales marked is shown by these circles, but whales from which marks have been recovered are additionally represented by crosses, each cross standing for one whale.

In the neighbourhood of the Shag Rocks to the north-west of South Georgia this system has not been followed in the case of Fin whales. There a circle of 70 miles radius has been drawn with the Shag Rocks as centre, and all the Fin whales marked within the area circumscribed have been plotted

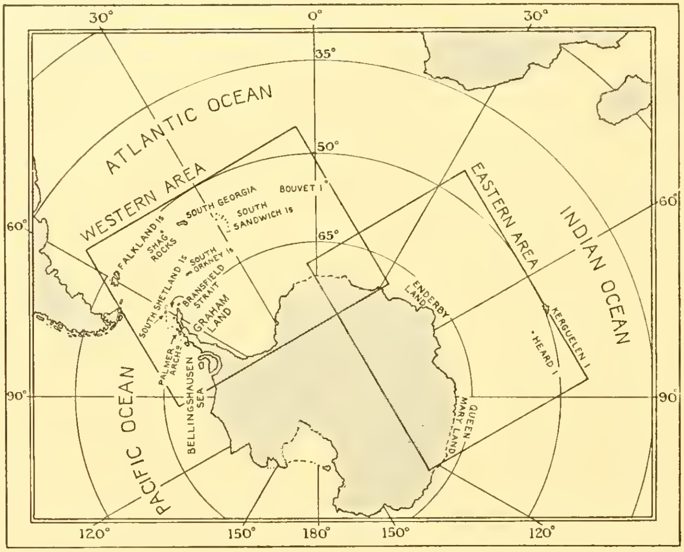


Fig. 1. Key chart showing place names and the two areas covered by Plates V–XXII.

together. The intense marking in this region was carried out from a hired whale catcher, and positions of the marked whales are in some cases recorded in the logs in such a way that they cannot be plotted so precisely as in other regions, although they do fall within the 70-mile circle. Also, it has been shown (Rayner, 1940, p. 261) that Fin whales marked within 70 miles of the Shag Rocks do not thence proceed directly to South Georgia, and there is thus some advantage in plotting them as a single unit, separate from those found farther east.

In the earlier paper (loc. cit.) the numbers of whales given as effectively marked were Blue 668, Fin 3915, Humpback 558, but the numbers used for the present paper are slightly lower, for they include only those actually recorded as hits, together with the few which, though recorded as misses or 'possibles', were subsequently recovered. The previous report included 'half the remaining possible hits' in the total, but these have now been disregarded. A few whales, viz. 16 Blues, 18 Fins and 4 Humpbacks, marked by the R.R.S. 'William Scoresby' in December when approaching the grounds fall a little beyond the boundaries of the charts used. Also some whales have been marked on

passages out and home and are not included; nor are those marked by R.R.S. 'Discovery II', all of which lie outside these charts. The numbers represented on the charts are:

	Blue		Fin		Hump	
	W	E	W	E	W	E
Nov.	38	—	142	—	(1)	—
Dec.	214	36	932	151	16	84
Jan.	96	105	1366	286	(7)	265
Feb.	(1)	122	187	431	33	105
Mar.	(7)	25	46	302	12	(2)

Charts are omitted where the number of whales marked during the month does not exceed ten; in the table these occurrences are indicated by the numbers in brackets.

The marking seasons have been of very variable lengths. On the eastern grounds the 'William Scoresby' marked for three seasons (1934–5, 1935–6 and 1936–7), commencing early in December and ending in March. On the South Georgia grounds the hired whale catcher started operations towards the end of November or in December, and continued to mid-January or early February. The 'William Scoresby's' season on the western grounds (1937–8) lasted from November to the latter half of February. No single month is complete for every season and expedition.

DISTRIBUTION OF WHALES MARKED

I. BLUE WHALES

(*a*) *Western Area*

(1) November (Plate V A). A few Blue whales have been marked during this month east of South Georgia on the grounds frequented by the whalers. The 'William Scoresby' in 1937 marked a few odd whales to the eastward between latitudes 56 and 58° S.

(2) December (Plate V B). Fair numbers were marked during this month south and east of South Georgia, mostly in 1934 and 1935. No Blue whales were marked from South Georgia in 1936. The 'William Scoresby' marked a very few near the Greenwich meridian at the extreme point of an easterly cruise.

(3) January (Plate VI). Few Blue whales were marked—less than half the December total—and these, to the south-east, south and west of South Georgia, were virtually all marked in 1935.

In February only one Blue whale was marked, and that was to the west of Grahamland. Only one Blue whale was marked in the South Georgia area during the season 1936–7.

(*b*) *Eastern Area*

The 'William Scoresby' was never very successful in the pursuit of Blue whales, and on no occasion were large numbers marked, the most successful season being 1936–7.

(1) December (Plate VII). A few were marked in this month in ones and twos, their distribution showing the arrival of the vessel at the pack-ice edge south of South Africa at the beginning of the season and the progress eastwards from there.

(2) January (Plate VIII). The small number of 105 marked in this month falls into an eastern group, mostly marked in 1937, and a western group off Enderby Land, mostly marked in 1935. The season 1935–6 yielded few Blue whales in this month.

(3) February (Plate IX). A few more Blue whales were marked in this month than in January, and these again fall into two similar groups, the western group lying farther to the westward. These western whales were largely marked in 1937, and the eastern group entirely in 1936.

(4) March (Plate X). Operations in this month were always confined to the western part of the area, as the ship was then lying conveniently for the commencement of the return voyage. Only a few Blue whales were marked.

It is noticeable that two grounds with a blank area between them are clearly shown by the marked whales. Very few Blue whales have been marked between 50 and 80° E and only two between 60 and 70° E.

II. FIN WHALES

(*a*) *Western Area*

(1) November (Plate XI A). Few Fin whales have been marked during November around South Georgia. The whale catcher only worked in this month during two seasons and then for only a few days; and an attempt in 1937 by the 'William Scoresby' to mark whales north of South Georgia during this month was foiled by bad weather. Towards the end of the month a few were marked at the beginning of a cruise to the eastwards. In 1934 a few Fins were marked to the south-east of South Georgia, and in 1935 a few in the vicinity of the Shag Rocks.

(2) December (Plate XI B). Large numbers of Fin whales, distributed widespread around South Georgia, have been marked in this month. Many were marked within 70 miles of the Shag Rocks, most of them in 1936. Another area of heavy marking lies to the east of South Georgia where many were marked in 1932, 1934 and 1935. A moderate number has been marked between 30 and 90 miles south of the island. The 'William Scoresby' in 1937 continued cruising eastwards as far as the Greenwich meridian, returning during the latter part of the month, but only moderate numbers of whales were marked.

(3) January (Plate XII). This has always been a very successful month for marking Fin whales around South Georgia. Large numbers, about 450, have been marked within 70 miles of the Shag Rocks, most of them in 1937 but also many in 1933 and in 1935. In 1936 many Fins were marked to the south-east of South Georgia. During the first half of this month in 1938 the 'William Scoresby' marked fair numbers between the South Sandwich group and the South Orkneys, and in the second half of the month small numbers to the west of the South Shetlands and Grahamland on a course into the Bellingshausen Sea.

(4) February (Plate XIII). Around South Georgia marking in this month took place only for a few days in 1937, resulting in a small number of whales being marked between the southern part of that island and Zavodovski Island in the South Sandwich group. In 1938 the 'William Scoresby' marked a moderate number of Fin whales to the west of Adelaide Island in the eastern part of the Bellingshausen Sea and in the Bransfield Strait.

(5) March (Plate XIV). A small number were marked in this month between 5° E and 10° E in 1935 and 1937.

(*b*) *Eastern Area*

(1) December (Plate XV). Most of the Fin whales marked in this month—and they are only a moderate number (169)—lie between 20 and 30° E where the 'William Scoresby' usually commenced operations on arriving at the pack-ice edge, as explained above under 'Blue whales'.

(2) January (Plate XVI). Only 286 Fin whales were marked in the eastern area this month. Those between 57 and 97° E were mostly marked in 1937; greater numbers, between 42 and 55° E, off Enderby Land were mostly marked in 1935.

(3) February (Plate XVII). This is the best Fin whale month in this region, with 431 whales marked. These are spread out in a rather scattered manner from 35 to 105° E, but between 20 and 35° E quite significant numbers were marked in 1935 and 1937. The most easterly whales were marked in 1936. It is to be noted that very few Fin whales were marked in January and February between 60 and 90° E, and almost all these were in 1937. This region was traversed several times in February, and in good weather, by the 'William Scoresby', but very few whales of any kind were seen.

(4) March (Plate XVIII). As mentioned above March was spent in the western part of the area preparatory to turning homewards. Moderate numbers (302) have been marked between 08° E and 56° E with the major number between 19 and 48° E—a rather similar distribution to February. All whales east of 20° E were marked in 1936, and those to the west of this meridian in 1935 and 1937.

III. HUMPBACK WHALES

(a) *Western Area*

The Humpback whale is now a rare animal in waters around South Georgia and the number marked in the vicinity of the island is insignificant.

(1) December (Plate XIX). A very few whales were marked by the 'William Scoresby' in 1937 on the easterly cruise.

(2) February (Plate XIX). Early in the month in 1938 when the 'William Scoresby' was off Adelaide Island a small number of Humpbacks were met and some marked. These may be the depleted descendants of the large numbers of Humpbacks which early in the century frequented the channels of the South Shetland and Palmer Archipelago, and which probably make their winter migration to the west coast of South America.

(3) March (Plate XIX). A very few were marked in 1937 about 10° E.

(b) *Eastern Area*

(1) December (Plate XX). A few Humpbacks were marked in 1934, 1935 and 1936 between 24 and 34° E when the ship arrived on the grounds, and a few in 1934 about 95° E.

(2) January (Plate XXI). This was the best month for Humpbacks, 265 having been marked; these were nearly all between 85 and 98° E, and were mostly marked in 1937 with a smaller number in 1936.

(3) February (Plate XXII). Fewer were marked in this month (107)—almost all in 1936 on the easterly grounds between 87 and 99° E.

The Humpback whale keeps to much more definite areas and to more definite routes of migration than Fin and Blue whales, and the distribution of marked Humpbacks demonstrates distinct division into an eastern and a western group. These points have been well proved by the recovery of marks (Rayner, 1940). Humpback whales are more numerous on the eastern grounds around 95° E than in the western area of concentration (about 20–40° E), but they are, to all intents, absent between these two areas. No Humpback has been marked between 60 and 70° E and virtually none between 40 and 80° E. This separation of two groups largely holds good for Blue and Fin whales.

During the whale-marking cruises of the 'William Scoresby', three of them in the eastern and one in the western area, a widespread search has been made for whales and the vessel has not remained in areas of proved or reputed abundance. It can, therefore, be accepted that the regions of concentration or scarcity of marked whales, seen in Plates V to XXII, do in fact represent in a considerable degree the concentrations or scarcities of the actual population of whales during the time of these cruises. On

the other hand, the area covered is immense for one vessel, and the finding of any large concentration of Fin whales (in which thirty or forty whales might be marked in one day) is easily a matter of chance. The marked whales do not therefore necessarily give a complete picture of the distribution of the population. Weather is a factor of the greatest importance in this form of hunting (as demonstrated by the experience of the whaling fleet in 1945–6), for bad weather, either in the form of poor visibility or gales, easily obscures a present abundance of whales. In these regions, however, January and February usually give good conditions with calm seas, good visibility and the long daylight so favourable to pursuit.

PLATE Va

Chart showing distribution of marked Blue whales, Western Area, for November.

PLATE Vb

Chart showing distribution of marked Blue whales, Western Area, for December.

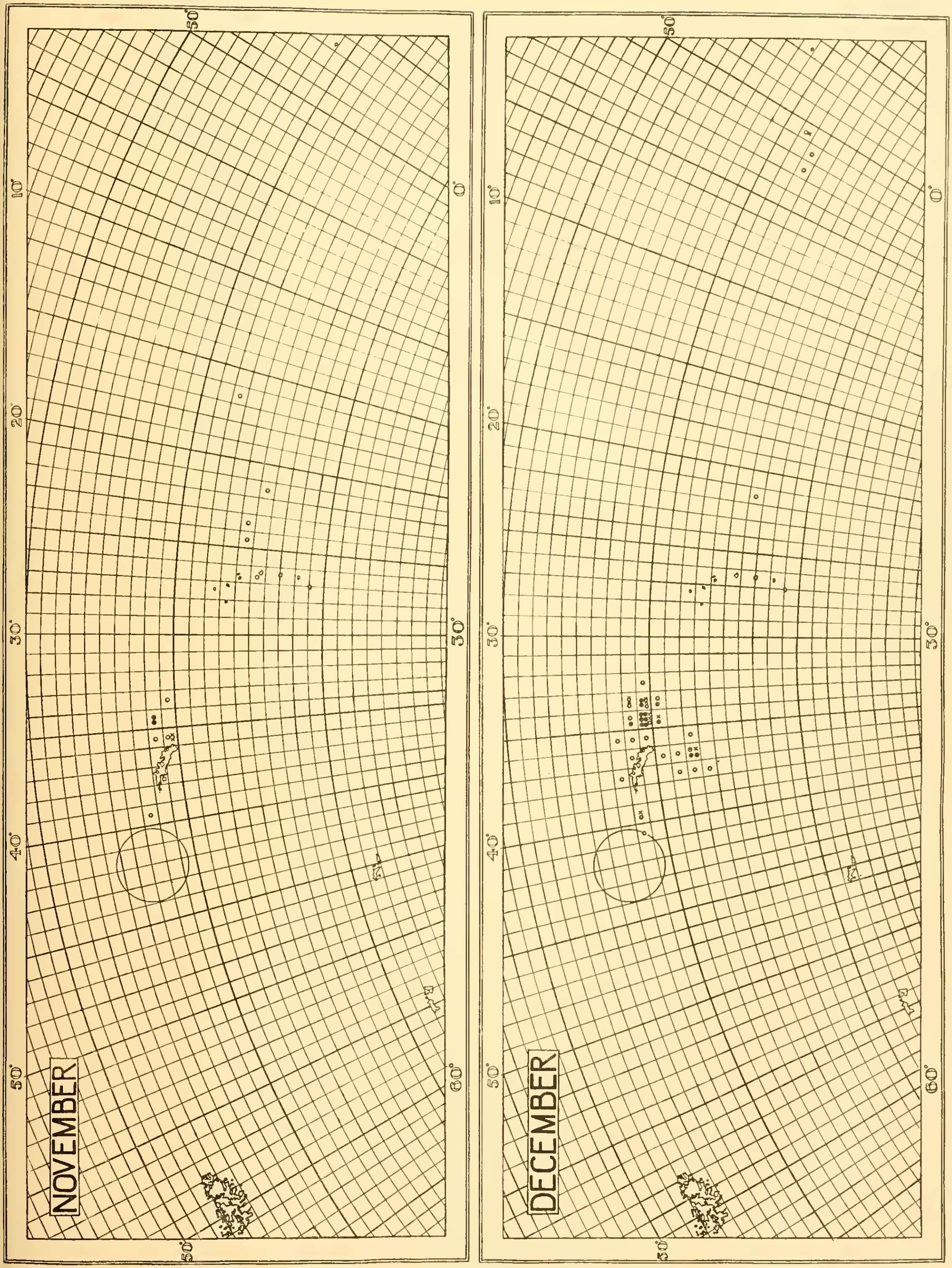

NOVEMBER
DECEMBER
50°
10°
20°
30°
40°
50°
0°
30°
60°

PLATE VI

Chart showing distribution of marked Blue whales, Western Area, for January.

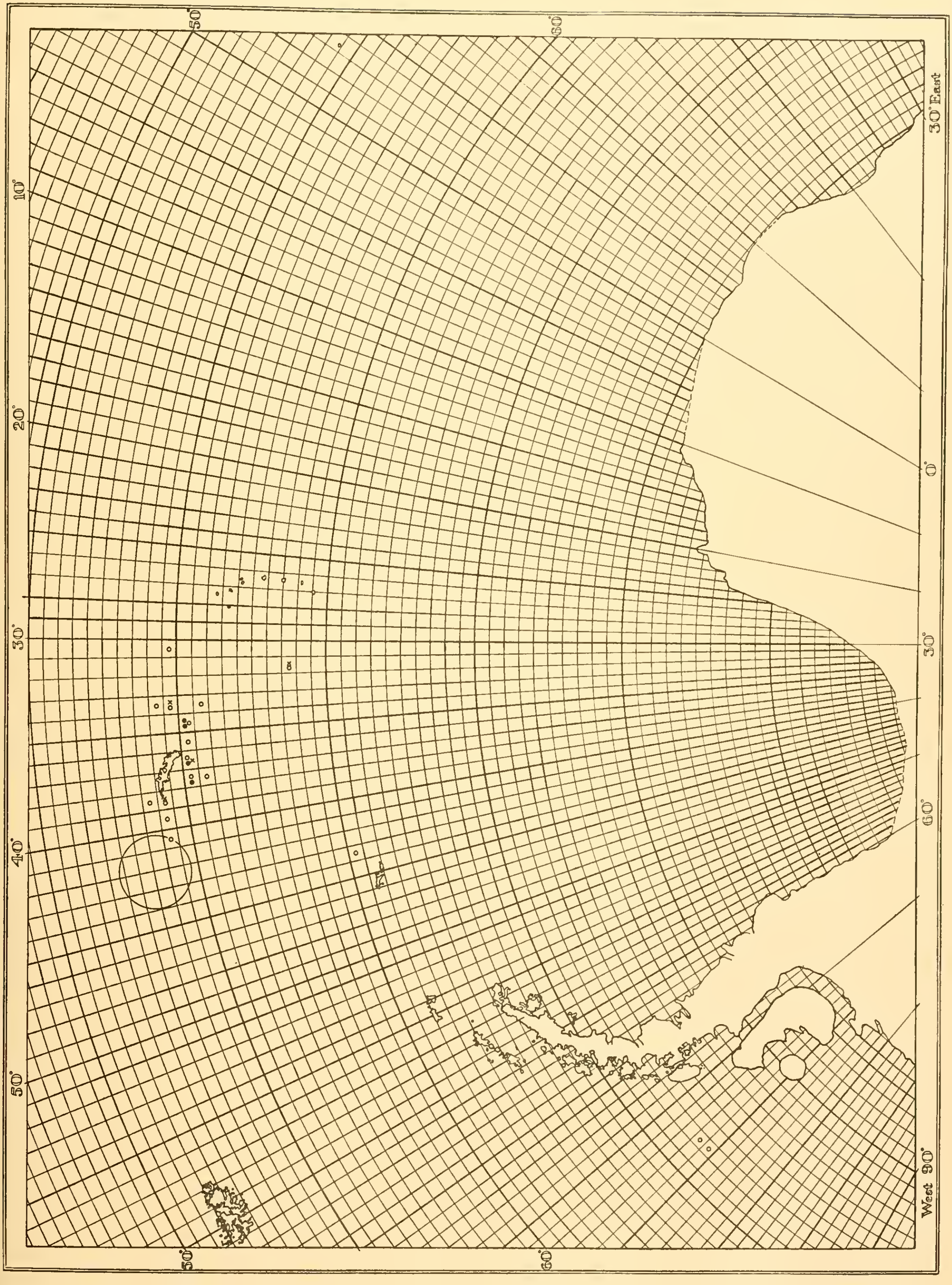

50°
60°
10°
20°
30°
40°
50°
30° East
0°
30°
60°
West 90°
50°
60°

PLATE VII

Chart showing distribution of marked Blue whales, Eastern Area, for December.

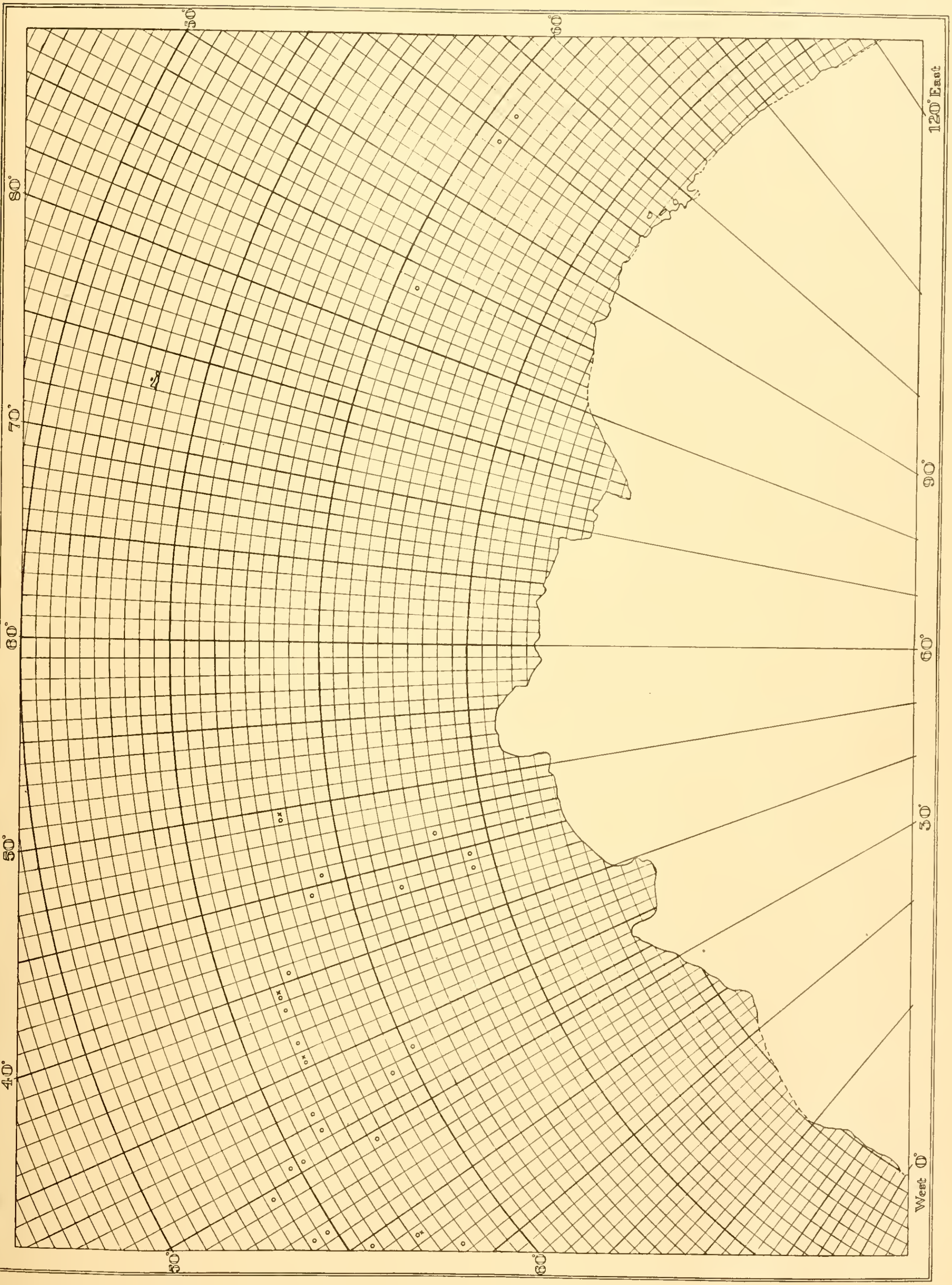

50°
60°
120° East
80°
70°
90°
60°
60°
50°
30°
40°
West 0°
50°
60°

PLATE VIII

Chart showing distribution of marked Blue whales, Eastern Area, for January.

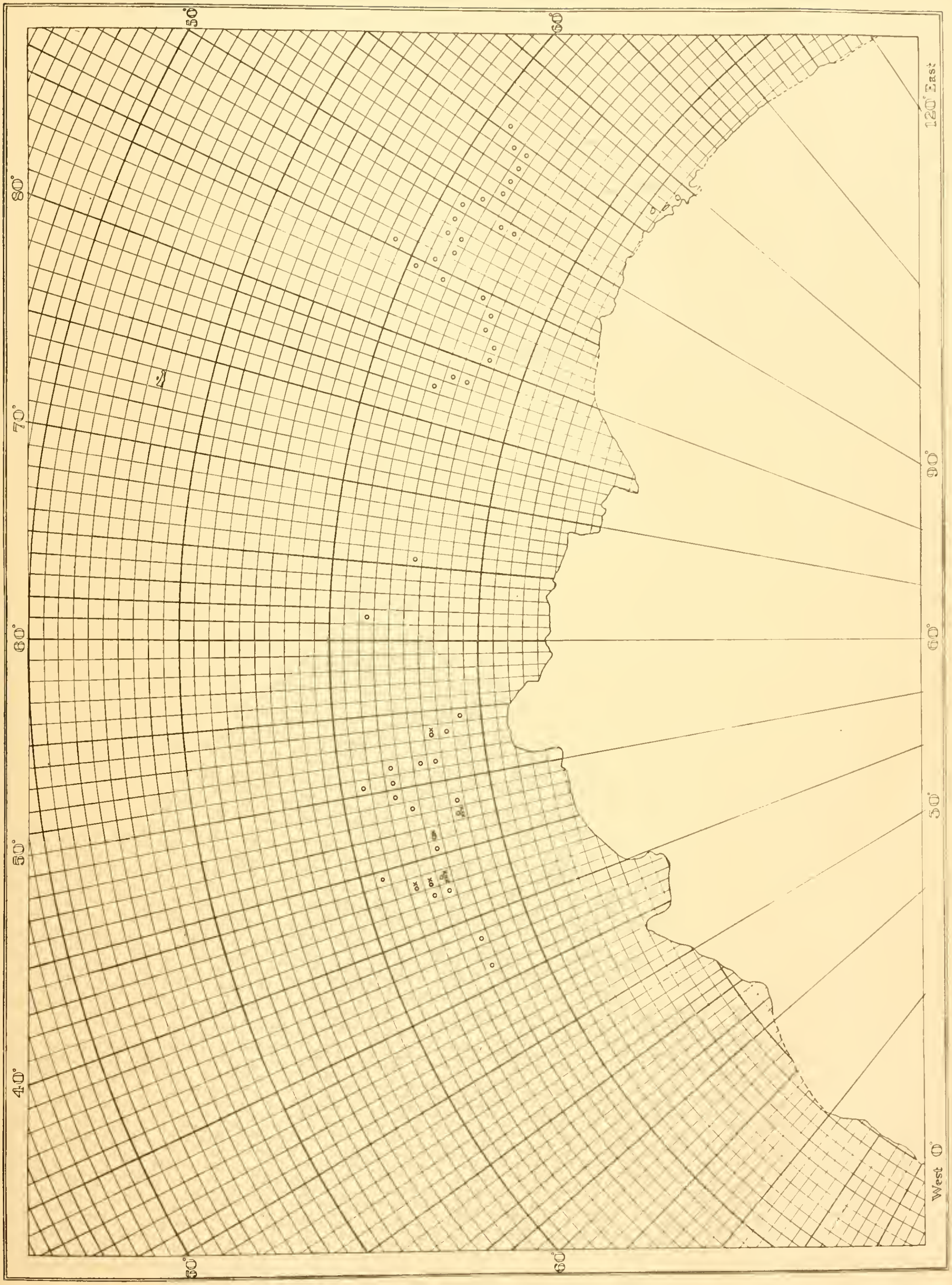

50°
60°
80°
70°
60°
50°
40°
120° East
90°
60°
50°
West 0°
50°
60°

PLATE IX

Chart showing distribution of marked Blue whales, Eastern Area, for February.

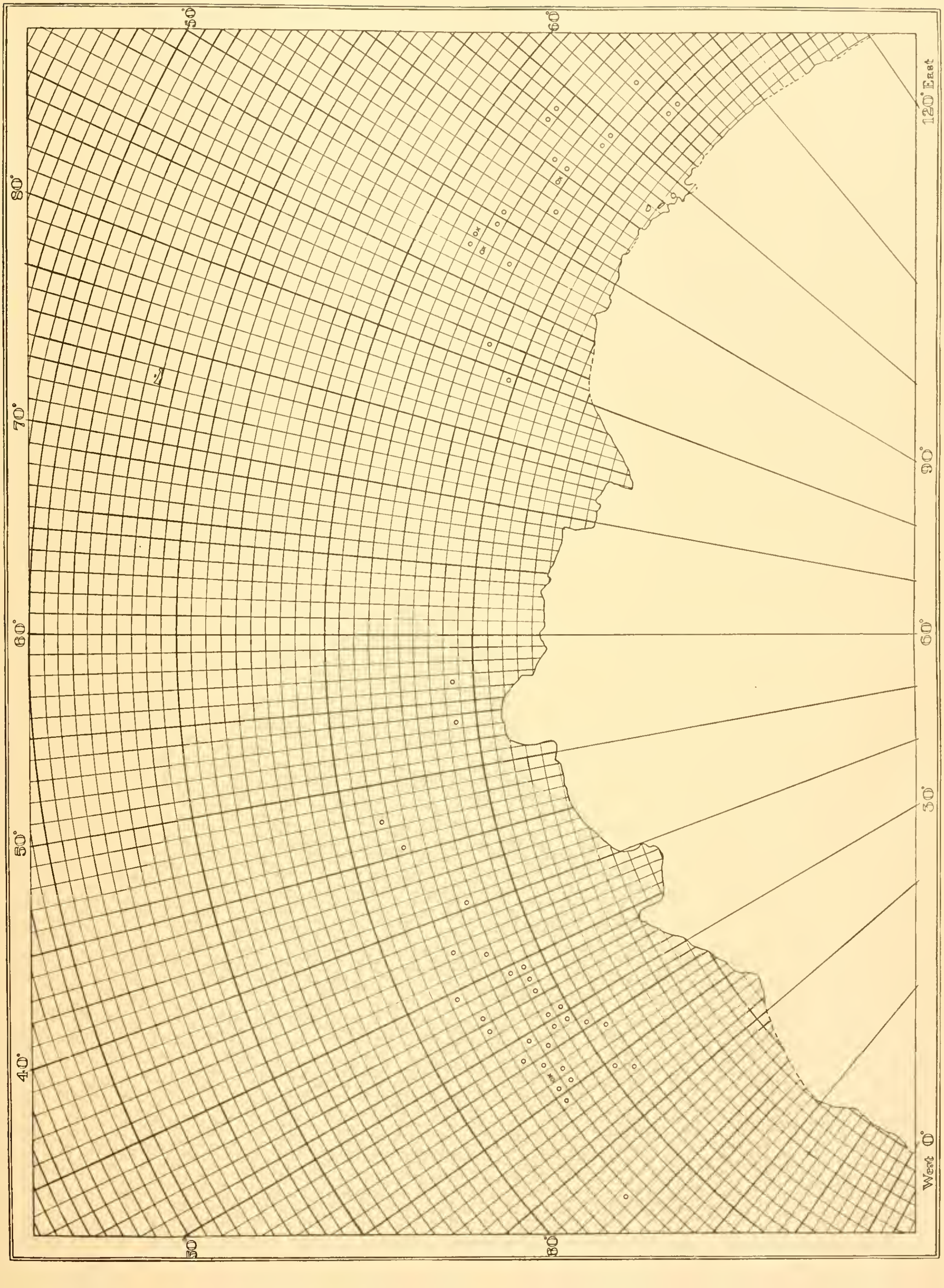

120° East
90°
60°
30°
West 0°
50°
60°
80°
70°
60°
50°
40°
50
80

PLATE X

Chart showing distribution of marked Blue whales, Eastern Area, for March.

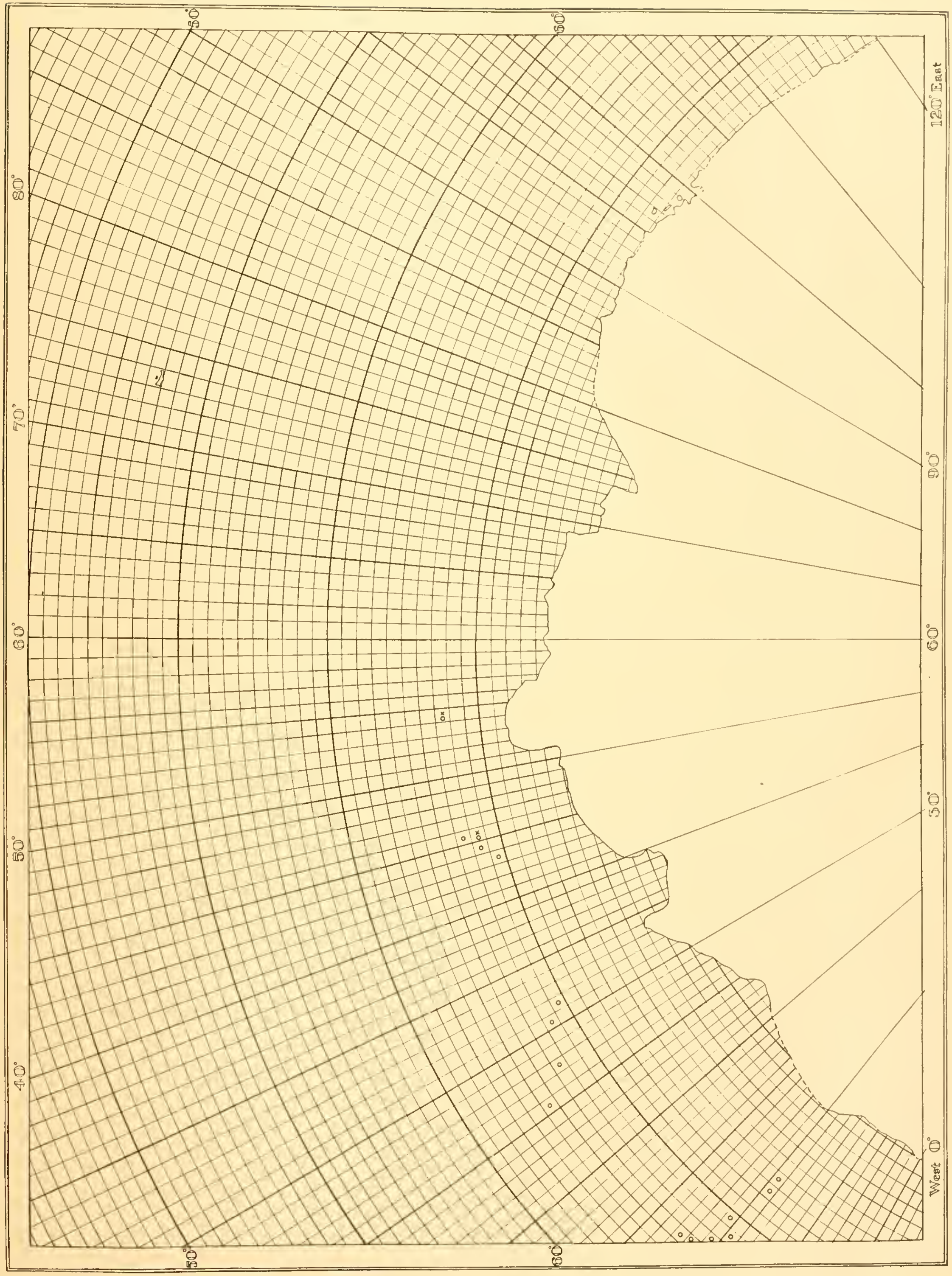

50°
60°
120° East
80°
70°
90°
60°
60°
50°
50°
40°
West 0°
50°
60°

PLATE XIa

Chart showing distribution of marked Fin whales, Western Area, for November.

PLATE XIb

Chart showing distribution of marked Fin whales, Western Area, for December.

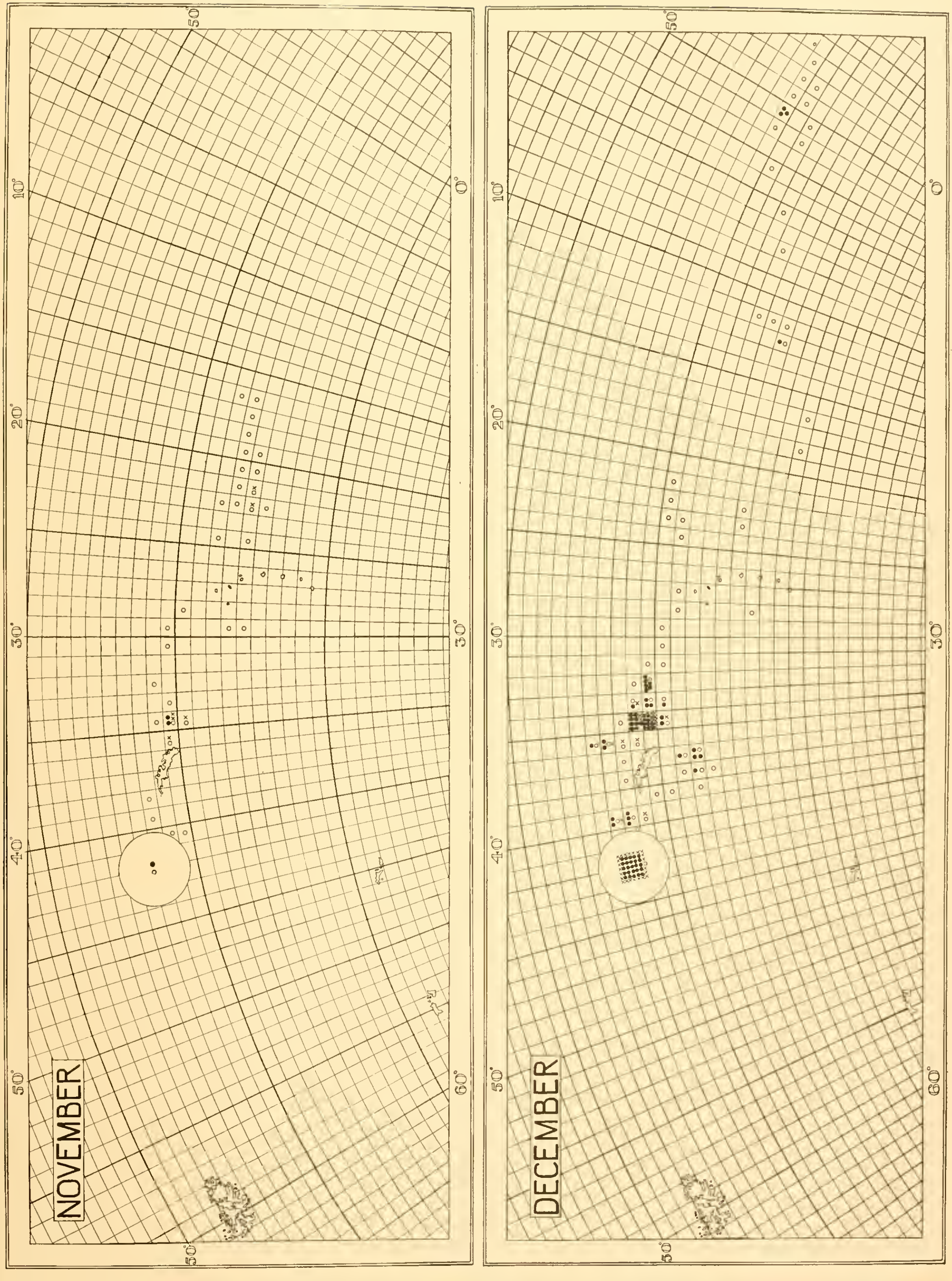

NOVEMBER
DECEMBER
50°
10°
0°
20°
30°
40°
50°
60°
50°

PLATE XII

Chart showing distribution of marked Fin whales, Western Area, for January.

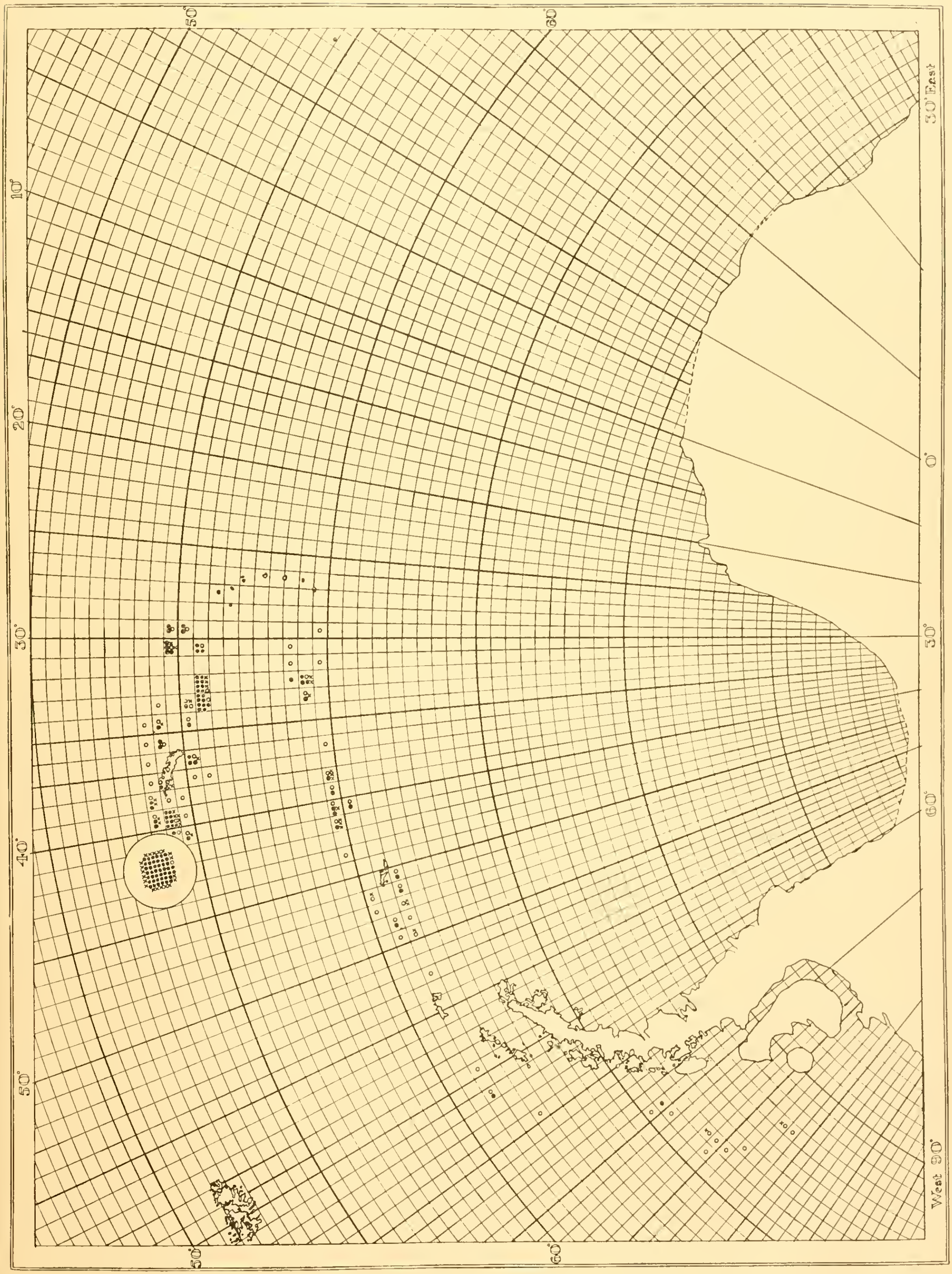

50°
60°
30° East
10°
20°
0°
30°
30°
40°
60°
50°
West 90°
50°
60°

PLATE XIII

Chart showing distribution of marked Fin whales, Western Area, for February.

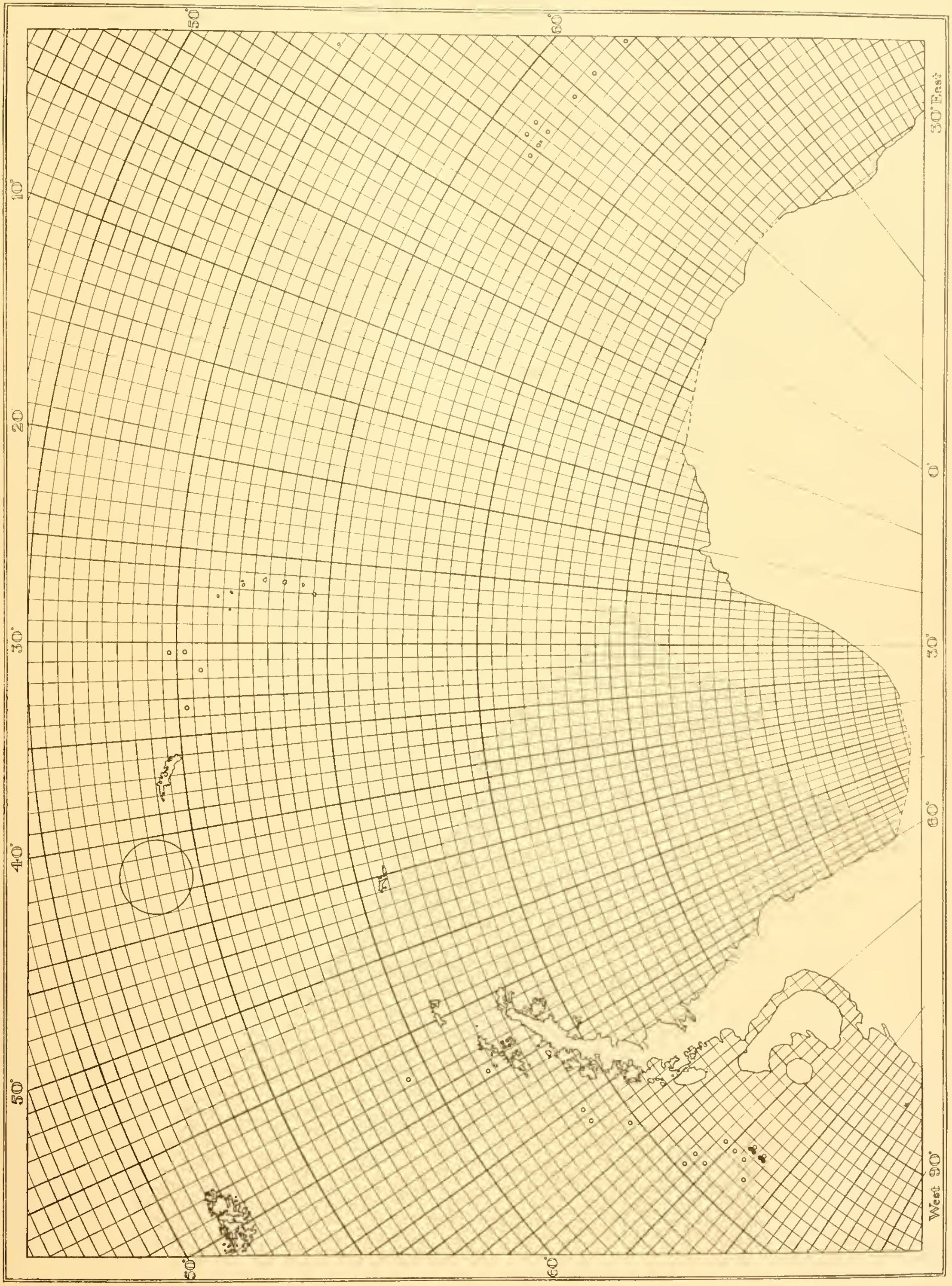

50°
60°
30° East
10°
20°
0°
30°
30°
60°
40°
50°
West 90°
50°
60°

PLATE XIV

Chart showing distribution of marked Fin whales, Western Area, for March.

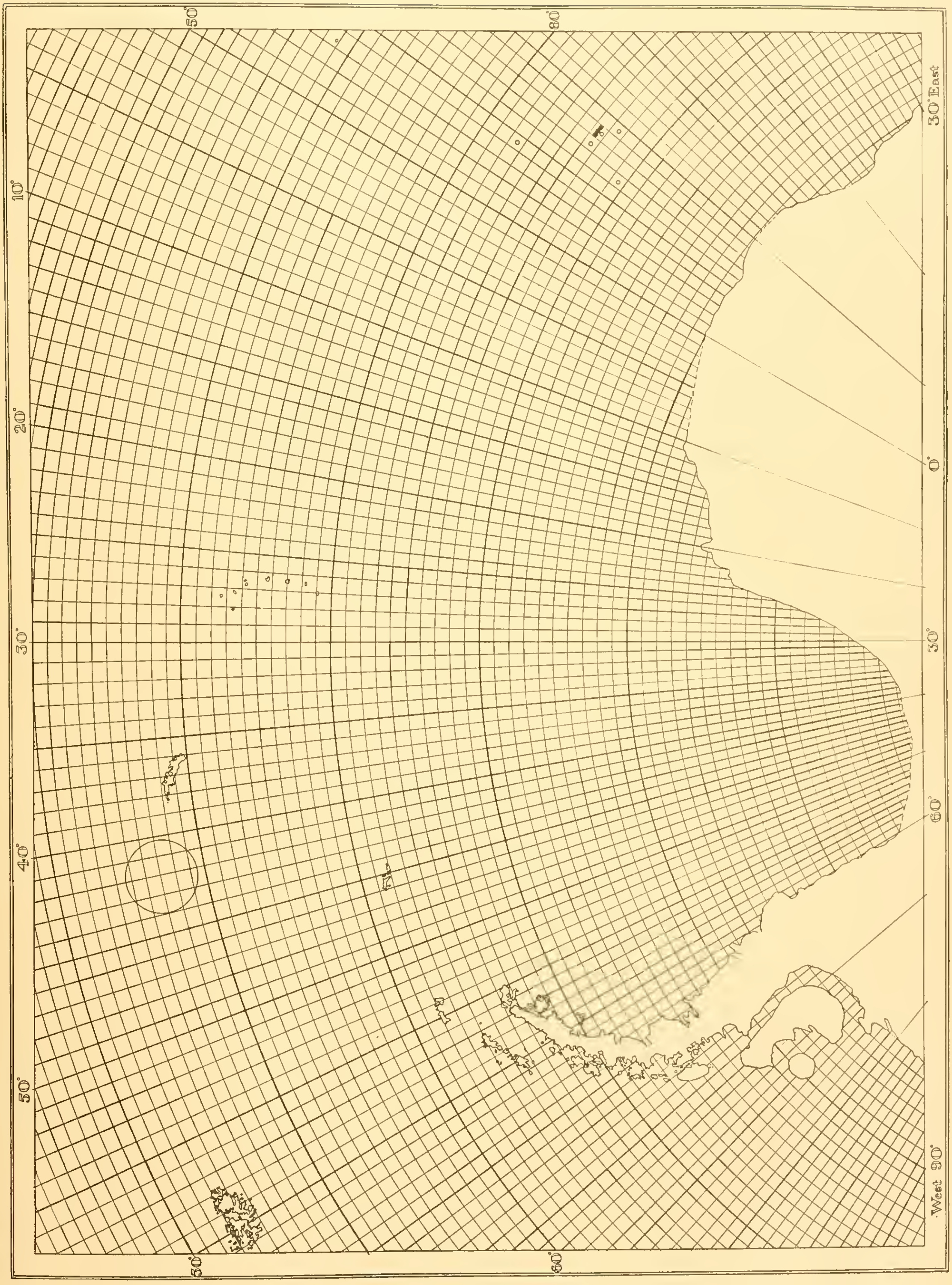

50°
80°
30° East
10°
20°
0°
30°
30°
60°
40°
50°
90° West
50°
60°

PLATE XV

Chart showing distribution of marked Fin whales, Eastern Area, for December.

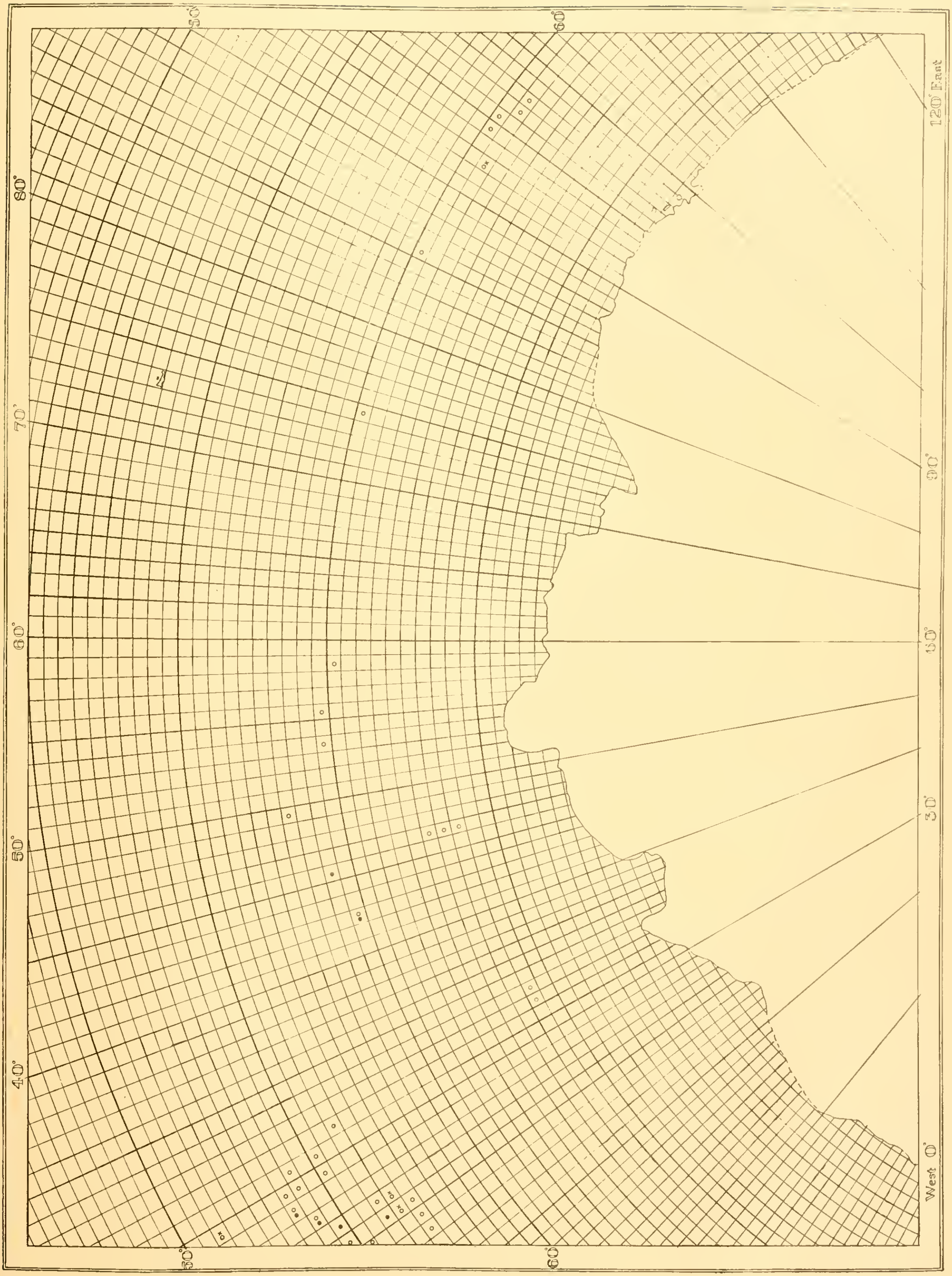

50°
60°
80°
70°
60°
50°
40°
120° East
90°
60°
30°
West 0°

PLATE XVI

Chart showing distribution of marked Fin whales, Eastern Area, for January.

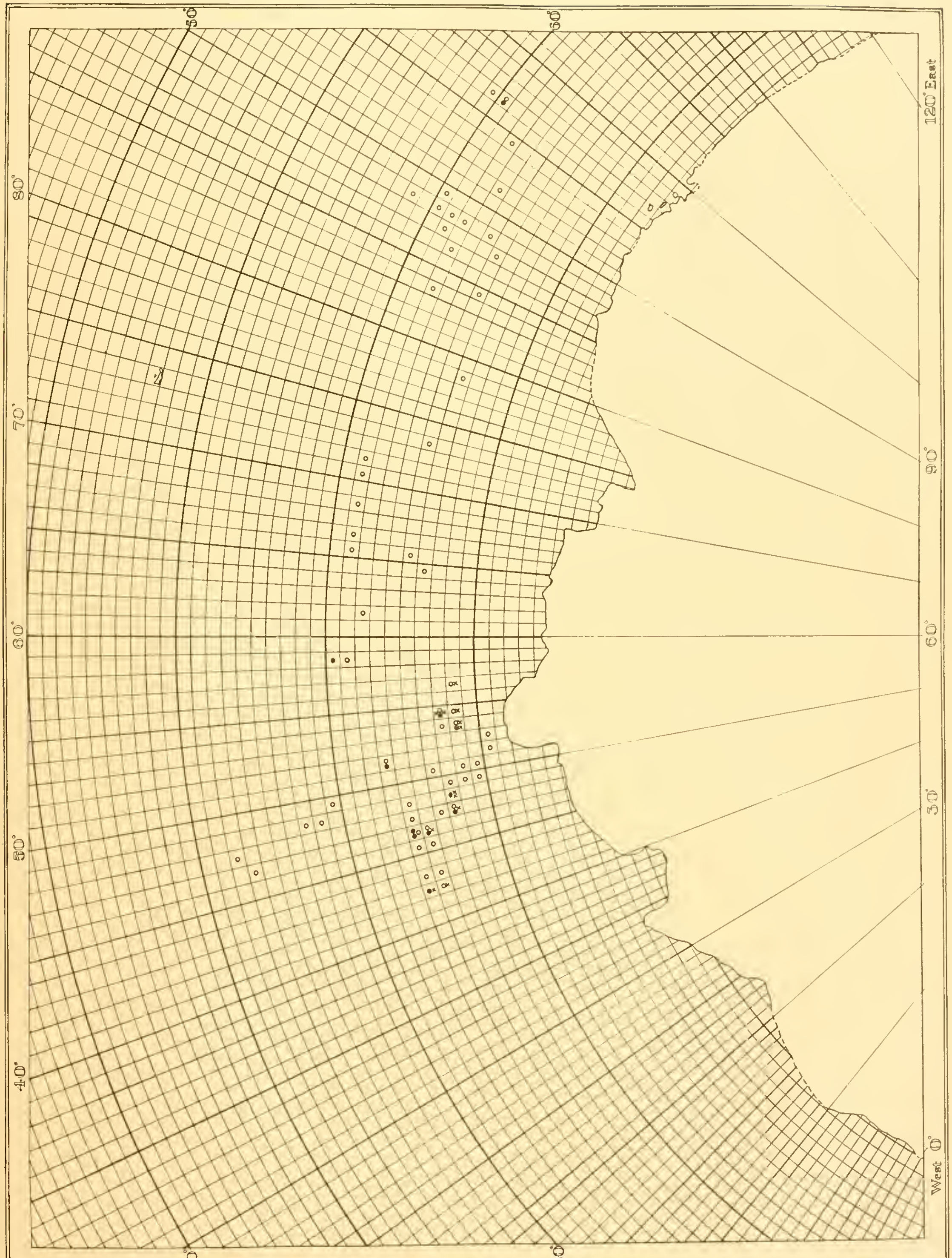

50°
60°
80°
70°
60°
50°
40°
120° East
90°
60°
30°
West 0°
50°
60°

PLATE XVII

Chart showing distribution of marked Fin whales, Eastern Area, for February.

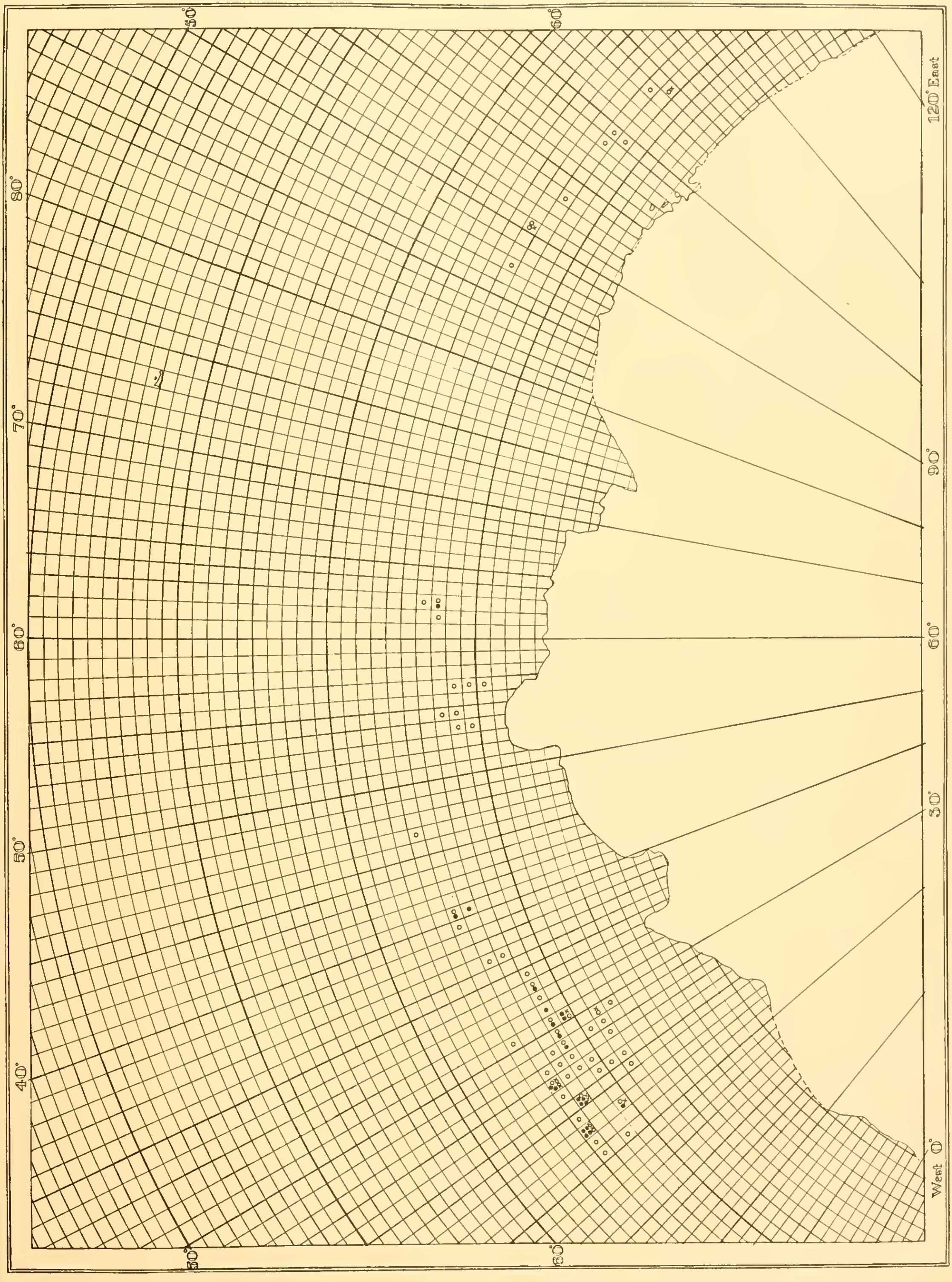

50°
60°
80°
70°
60°
50°
40°
120° East
90°
60°
30°
West 0°
50°
60°

PLATE XVIII

Chart showing distribution of marked Fin whales, Eastern Area, for March.

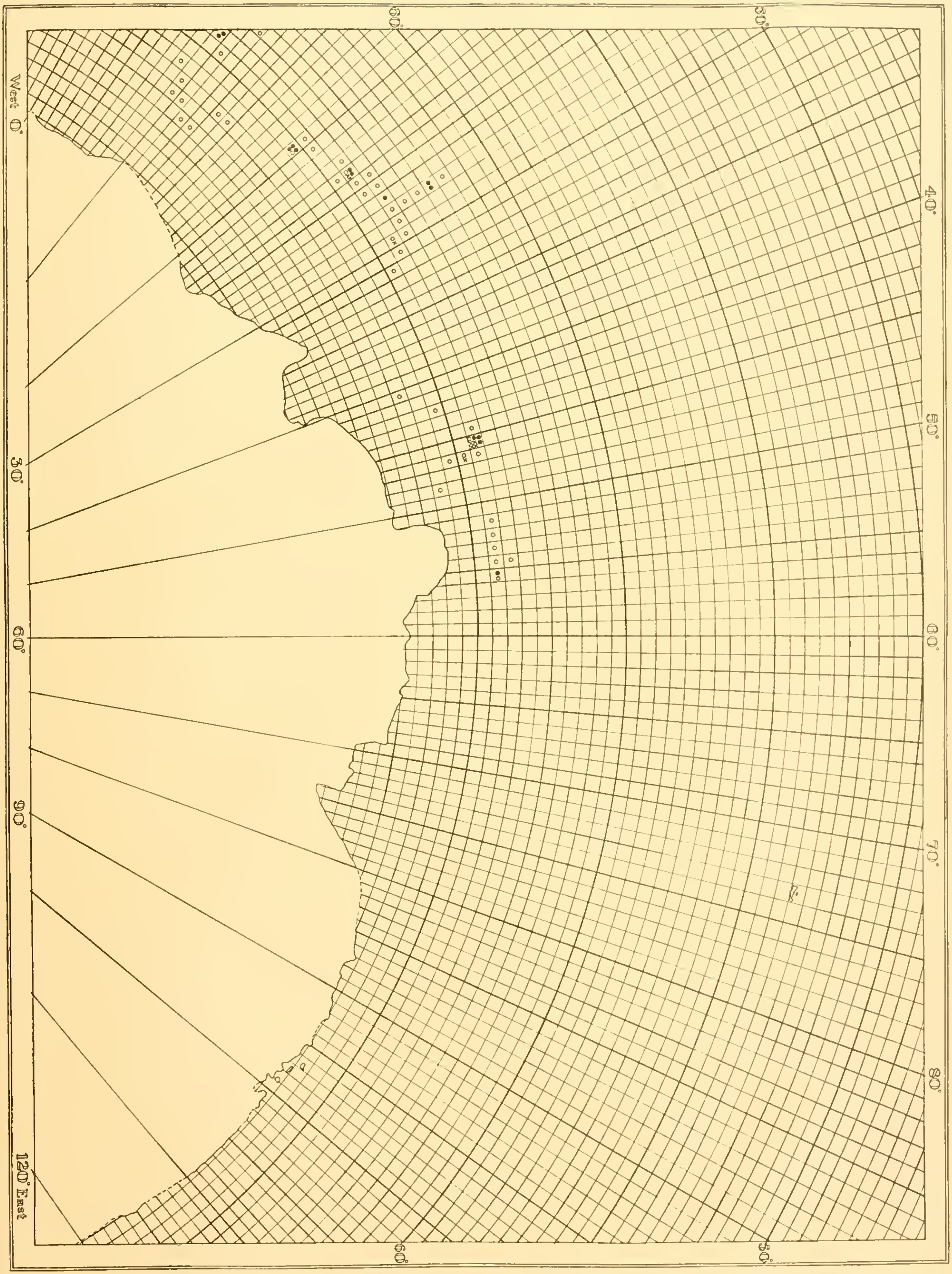

West 0°
30°
60°
90°
120° East
60°
30°
40°
50°
60°
70°
80°
60°
50°

PLATE XIX

Chart showing distribution of marked Humpback whales, Western Area, for December, February and March.

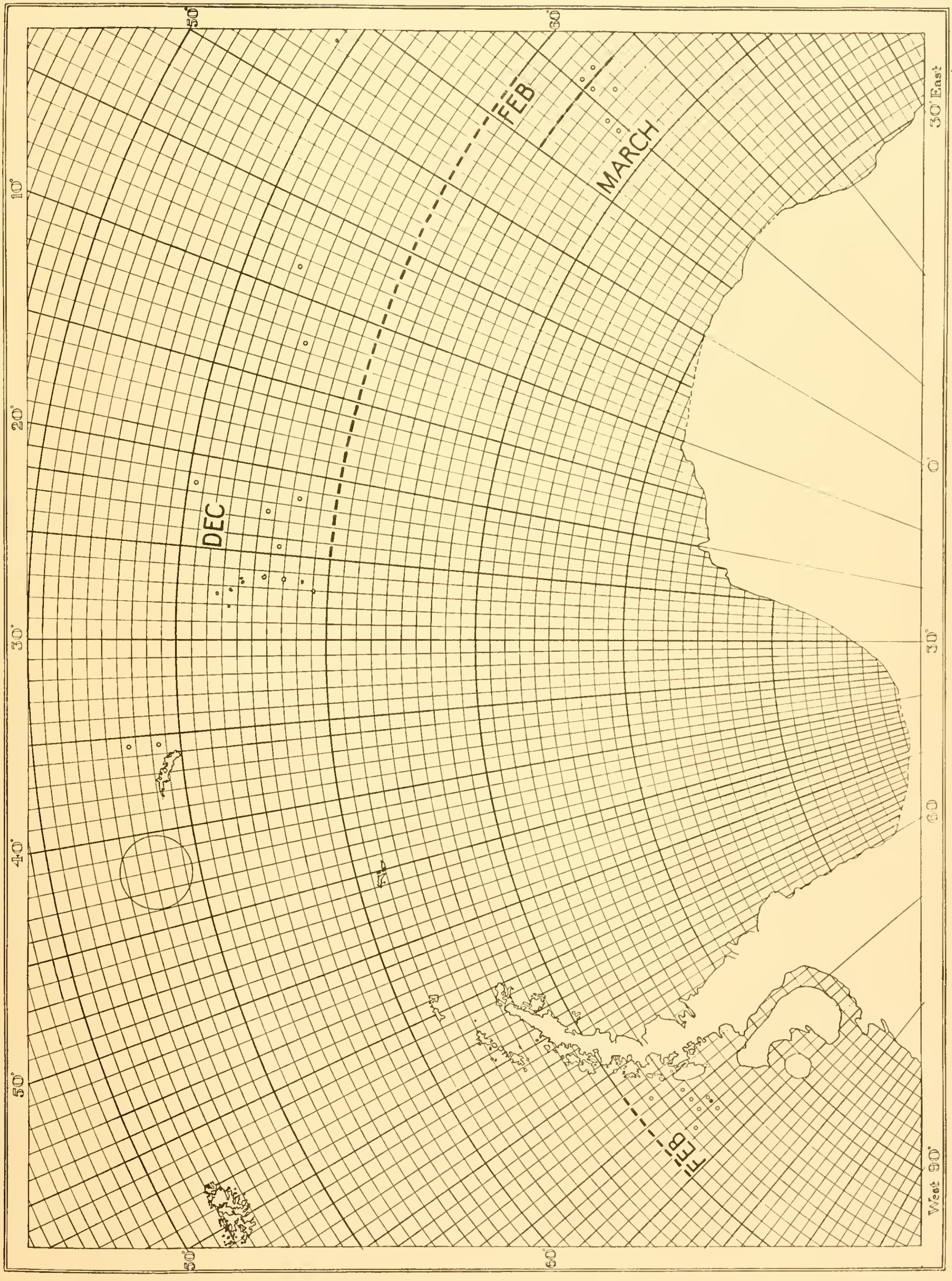

50°
60°
FEB
MARCH
30° East
10°
20°
0°
DEC
30°
30°
60°
40°
50°
FEB
West 90°
50°
60°

PLATE XX

Chart showing distribution of marked Humpback whales, Eastern Area, for December.

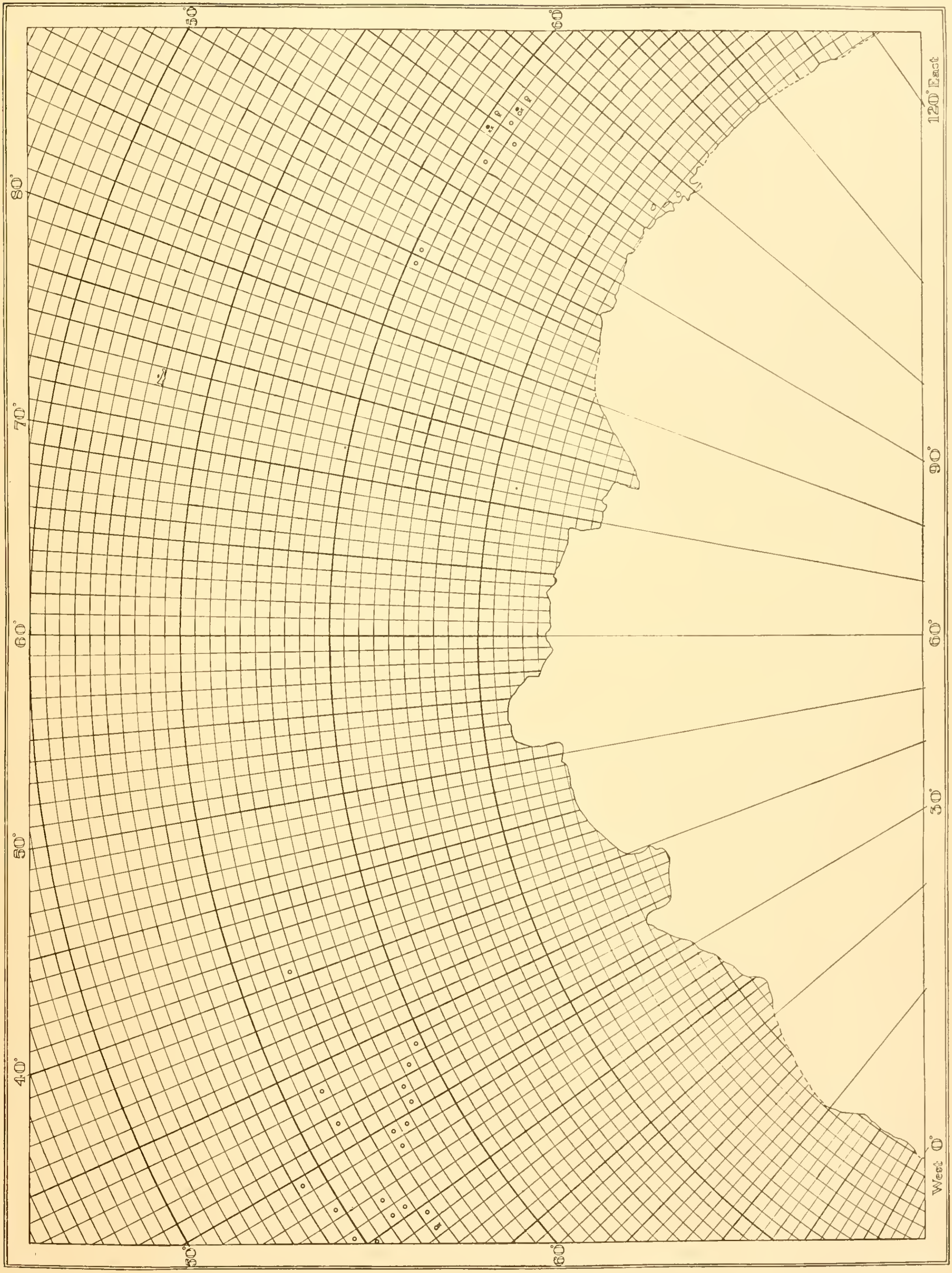

50°
60°
120° East
80°
70°
90°
60°
60°
50°
30°
40°
West 0°
50°
60°

PLATE XXI

Chart showing distribution of marked Humpback whales, Eastern Area, for January.

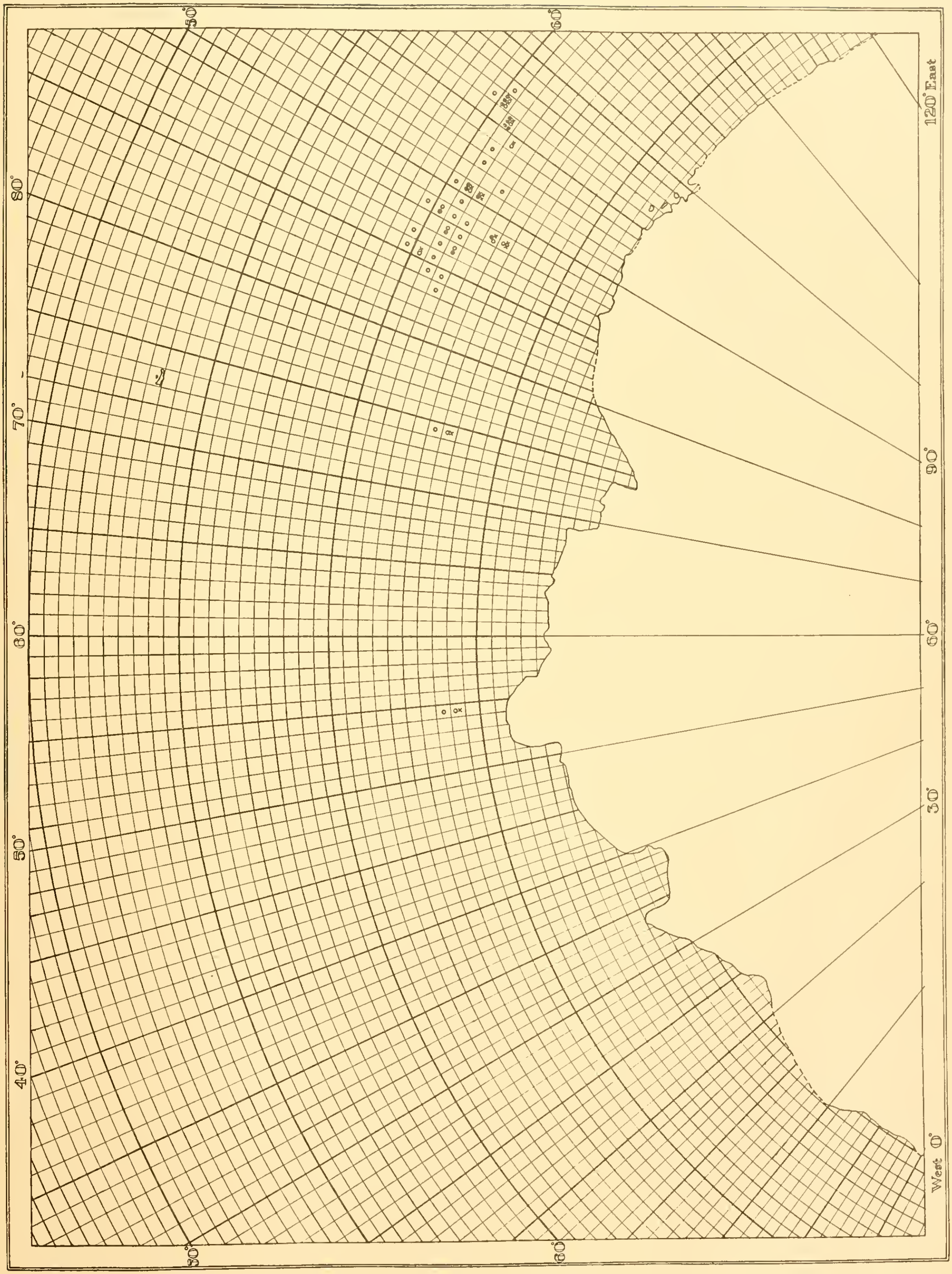
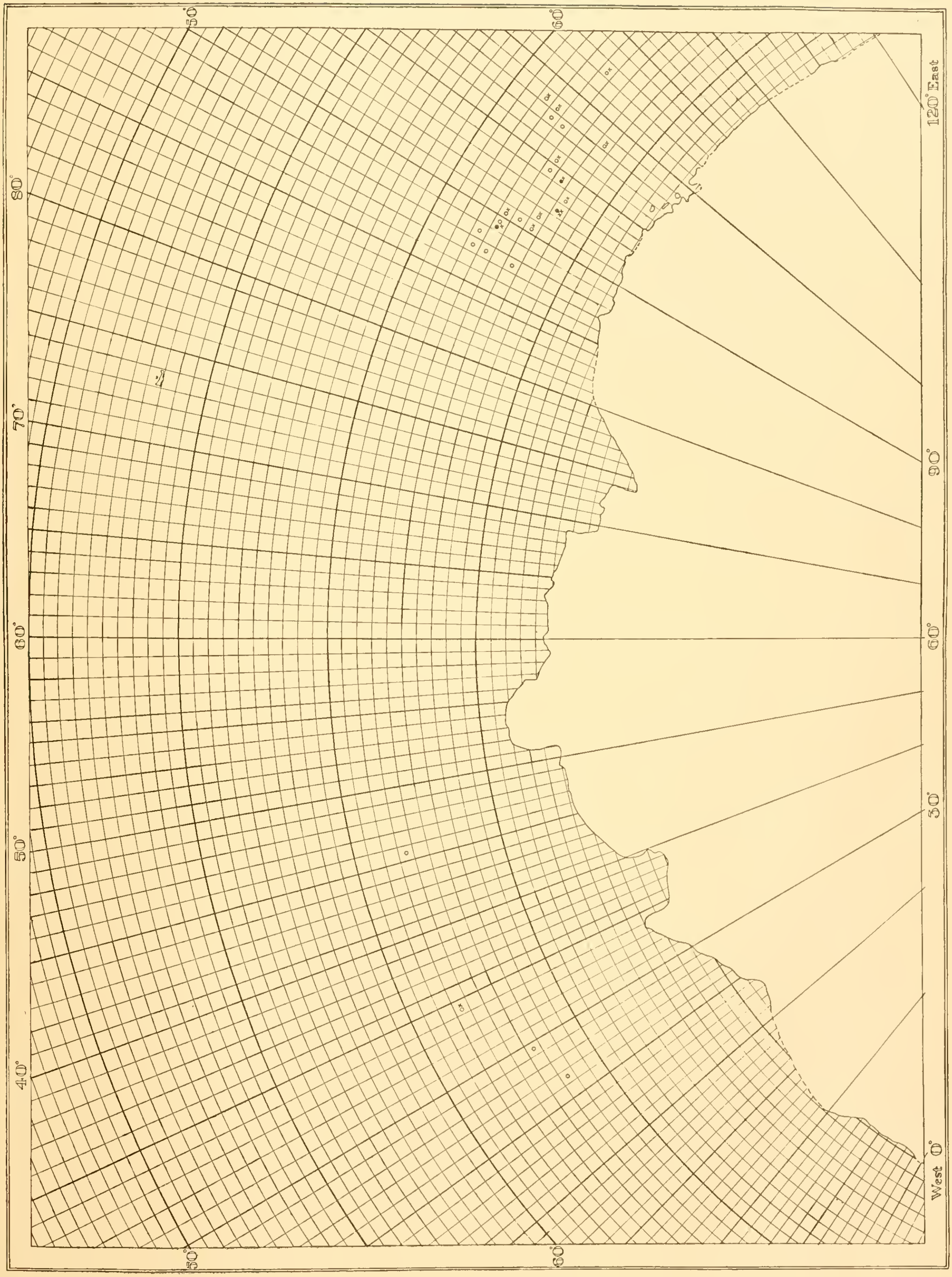

50°
60°
80°
70°
60°
50°
40°
50°
60°
120° East
90°
60°
30°
West 0°

PLATE XXII

Chart showing distribution of marked Humpback whales, Eastern Area for February.


50°
60°
120° East
80°
70°
90°
60°
60°
50°
50°
40°
West 0°
50°
60°

SOUNDINGS TAKEN DURING THE DISCOVERY INVESTIGATIONS, 1932–39

By H. F. P. Herdman, M.Sc.

(Text-figs. 1–19, Plates XXIII–XXXI)

INTRODUCTION

The oceanic soundings taken by the R.R.S. 'Discovery', 'Discovery II' and 'William Scoresby' from 1926 to 1932 have been dealt with in a previous report (Herdman, 1932). Most of the soundings in that period were in the West Antarctic region, and the report included descriptions of the sounding equipment then in use, an account of the Scotia Arc and its significance, comments on the bottom topography of the Scotia Sea and neighbouring regions, and bathymetric charts of the Scotia Sea, the vicinity of South Georgia, and the Bransfield Strait and adjacent waters. Between 1932 and 1939 many thousands of additional echo soundings (far more than in the period before 1932) were taken by the 'Discovery II', together with a small number of Lucas soundings taken on station by the 'William Scoresby' and by the 'Discovery II' when her deep-water echo-sounding set was temporarily out of order. These new soundings are spread over nearly all parts of the Southern Ocean (see Text-fig. 18, p. 89); they greatly amplify the previous soundings in the West Antarctic region; and they throw much new light on some areas of special interest. Owing to the dispersal of the Discovery Committee's staff during the years of war this very large accumulation of data could not be analysed until now.

Although many unpublished oceanic soundings are available, the time has hardly come for a new bathymetric chart of the Southern Ocean. Nevertheless, the data justify a review of the bottom topography associated with the Scotia Arc, an account of soundings taken during various hydrographic surveys, and an account of certain localities in which the bathymetric features are of some oceanographical or geological significance. When deep-sea echo soundings are undertaken on a large scale, especially in regions of much bad weather, many practical difficulties arise which have not been adequately dealt with in previous publications. In the following pages, therefore, and in Appendix I considerable attention is given also to technique; and the interpretation of individual soundings and continuous records is also discussed.

The present report is based on the Discovery Committee's data, but in the preparation of the contour charts soundings from all available sources have been used, especially in the Ross Sea area, where a considerable number of echo soundings were taken between the years 1933 and 1935 by the second Byrd Antarctic Expedition. In the Scotia Sea area and in the Bransfield Strait we have used the full results of the 'Meteor' sounding programme, which agree well with our own observations. With these exceptions the number of soundings from other sources in the areas concerned is almost negligible and in most instances adds little or nothing to the information obtained from our own observations. In fact, our intensive sounding programme has shown that either the position or depth of some of the earlier soundings from other sources is quite unreliable.

Soundings taken by the 'Discovery II' may be roughly classified in three main groups: (*a*) Routine oceanic soundings, normally taken every hour when on passage, at every scientific station and when steaming between stations, (*b*) Soundings taken during hydrographical survey work, and (*c*) Special soundings taken on the occasions when a submarine ridge, bank or other interesting feature of the ocean floor was being crossed. The routine soundings (*a*) were usually obtained under way at normal

cruising speed, i.e. 9 knots. If, however, conditions were unsuitable for this and it was important that the line of soundings should be as complete as possible then the ship was either manœuvred with regard to sea and wind or hove-to for a few minutes until the sounding had been completed. For (*b*) soundings were taken as often as the scale of the survey required, and in later years a continuous record from the recording machines was our aim. At times this entailed twelve to fourteen hours continuous running of the automatic recorders, which were fitted in recent years; but with the exception of minor breakdowns these machines generally stood up well to the work. Special soundings (*c*) were usually taken whenever any known ridge or bank was being crossed or when the hourly sounding showed any marked change in depth. In the earlier years when only 'listening' sets were fitted the spacing of the soundings was decided according to the condition of sea and weather, or to the slope of the bottom. In recent years it was the practice to try for a continuous record over the area concerned.

In this report prominence has been given mainly to oceanic and special soundings, since the detailed soundings taken on hydrographical surveys have only a limited value so far as hydrological conditions in the oceans are concerned. Nor are they of much value in the determination of major geological features. The soundings taken during the survey of the South Orkney Islands have already been shown on the chart published with a report on those islands by Marr (1935), but the intensive soundings taken in the South Shetland Islands between 1934 and 1937 have not, as yet, been examined by us in detail.

The positions of the soundings taken by the 'Discovery II' and discussed in this report were determined as follows: From 1932 to 1935, by Lt. A. L. Nelson, R.N.R.; from October 1935 until June 1937 by Lt. R. Walker, R.N.R.; and for the period of September 1937 to May 1939 by Lts. L. C. Hill, O.B.E., R.N.R. and A. F. Macfie, R.N.R. The careful work and willing co-operation of these officers has done much to assist me in the preparation of this report. From 1932 until early in 1936 all the soundings were plotted by these officers on large-scale charts, but from 1936, in order to meet the wishes of the Hydrographer of the Navy, lists of soundings and their positions were prepared at regular intervals, and plotting was thus discontinued except during survey work.

This report has been considered in manuscript by Mr J. M. Wordie, C.B.E., M.A. and the Hydrographer of the Navy (Rear-Admiral A. G. N. Wyatt, C.B., R.N.); to them I am grateful for advice and valuable suggestions. It has also been read by the Superintending Scientist of H.M. Underwater Detection Establishment (Mr J. Anderson, O.B.E.) and several members of his staff. To one of them, Mr J. H. Hayes, a pioneer of the earlier experimental work in deep-sea echo sounding, I am much indebted for very helpful criticisms and advice on certain technical points.

In the preparation of the figures and contour charts I have received considerable assistance from the Hydrographic Department of the Admiralty, especially from the Superintendent of Charts, Captain E. H. B. Baker, D.S.O., R.N. Through his courtesy I have been able at any time to consult our original survey charts and plans, now in the possession of the Hydrographic Department.

Finally, I should like to express my gratitude to Dr N. A. Mackintosh for the help he has so freely given me at all stages in the preparation of this report. His practical experience of the sounding routine in the 'Discovery II' has materially assisted me in the presentation of what I hope is a balanced account of our sounding work.

SOUNDING EQUIPMENT

When the previous report was written the 'Discovery II' was fitted with Lucas and Kelvin machines for wire soundings, and with deep and shallow echo-sounding sets of the 'listening' pattern. A full description of these instruments and their positions in the ship has been given already in the earlier

sounding report, and particulars appear also in the report on the R.R.S. 'Discovery II' by Ardley and Mackintosh (1936, pp. 102–4). Though little used in recent years, the Lucas and Kelvin sounding machines remained as part of our standard sounding equipment; some amplification, however, of the description of the echo-sounding sets given in the latter report is required, and details will be found here in Appendix I (p. 95).

DEEP-WATER ECHO-SOUNDING SET

During the six years in which the 'Acadia' type recorder was used with the deep-water echo-sounding set, little electrical or mechanical trouble was experienced with the recorder mechanism, and records covering some 900 hours of running were made and stored. Very approximately this represents a continuous survey of about 6000 miles of the ocean floor, from which a virtually permanent record is available, but the recorder was used also on numerous occasions for short periods up to 20 minutes from which the record itself was not kept, but from which soundings had been noted. The positions of the great majority of these oceanic records are shown in Text-figs. 1 and 2. A large proportion of the stored records were taken during the running surveys of the South Shetland and South Orkney Islands and the tracks of the ship at these times are shown in detail in Text-figs. 3 and 4 together with the tracks of records taken at Tristan da Cunha, South Georgia, the Balleny group and other islands. A considerable number of continuous records were also obtained in open water and across such features as the Burdwood Bank, the Kerguelen-Gaussberg Ridge and a newly discovered bank in 42° S, on the meridian of Greenwich. The depths recorded varied from 25 fm. (46 m.), the average minimum depth at which soundings could be read,[1] to just over 3000 fm. (5486 m.), which was the greatest depth at which we obtained a clear record. A complete list of all records, with their positions, is given in Appendix II (p. 98) to this report. In Appendix I (p. 95), which deals mainly with certain technical difficulties met with in the operation of the echo-sounding sets, reference will also be found to the effect of extraneous noises on the echo marking on these records. Water noises and the passage of the ship through pack-ice can completely obscure the echo marking, but on the whole our records are very free from interference from these sources.

SHALLOW-WATER ECHO-SOUNDING SET

The sonic pattern 'listening' set, described in our previous reports, was in use until 1935, and was then replaced by an Admiralty System Magnetostriction set with a Mark XIID recorder. This is a supersonic set (emitting soundwaves beyond the audible range) and it was manufactured and fitted by Messrs Henry Hughes & Son Ltd. The principle of the British Admiralty system of supersonic echo sounding with magnetostriction transmission is well known and has already been described in considerable detail in the *Hydrographic Review* (1934, 1936 and 1937). It is sufficient, therefore, to say that the range of this new set was 0–130 fm. (0–238 m.) on the slow or normal speed, with one phase addition of 100 fm., making the total range 0–230 fm. (0–421 m.). On the fast speed soundings were obtained in feet, with a corresponding range of 0–230 ft. (0–70 m.).

Few difficulties arose in the operation of this set, but there are certain technical points on which fuller information appears desirable. This information, together with the details of the arrangement of the transmitter and receiver in the hull of the 'Discovery II', will be found in Appendix I (p. 95).

[1] At depths less than 25 fm. (46 m.) the echo marking on the 'Acadia' record tended to merge with the transmission band. Reduction of the sensitivity of the receiving circuit allowed the echo marking to be clearly distinguishable at lesser depths but, to allow for greater accuracy in the shallower soundings, it was our normal practice to use the shallow machines for soundings less than 50 fm. (91 m.).

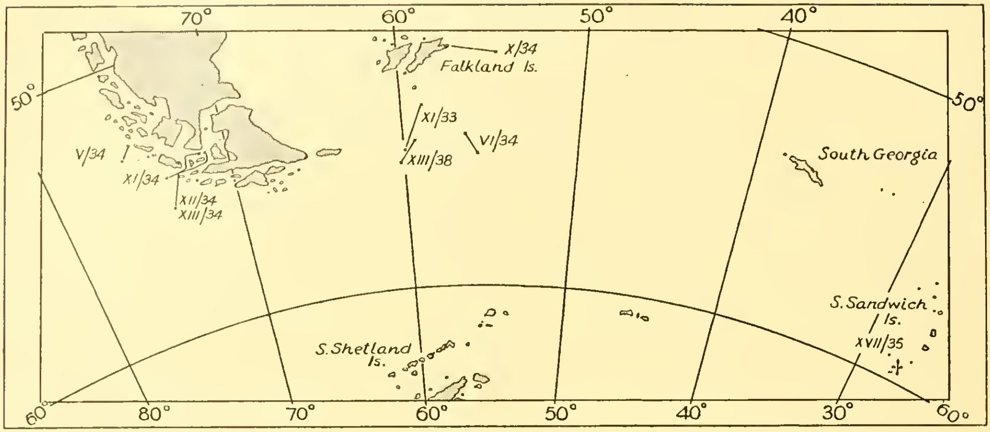


Fig. 1 (*a*).

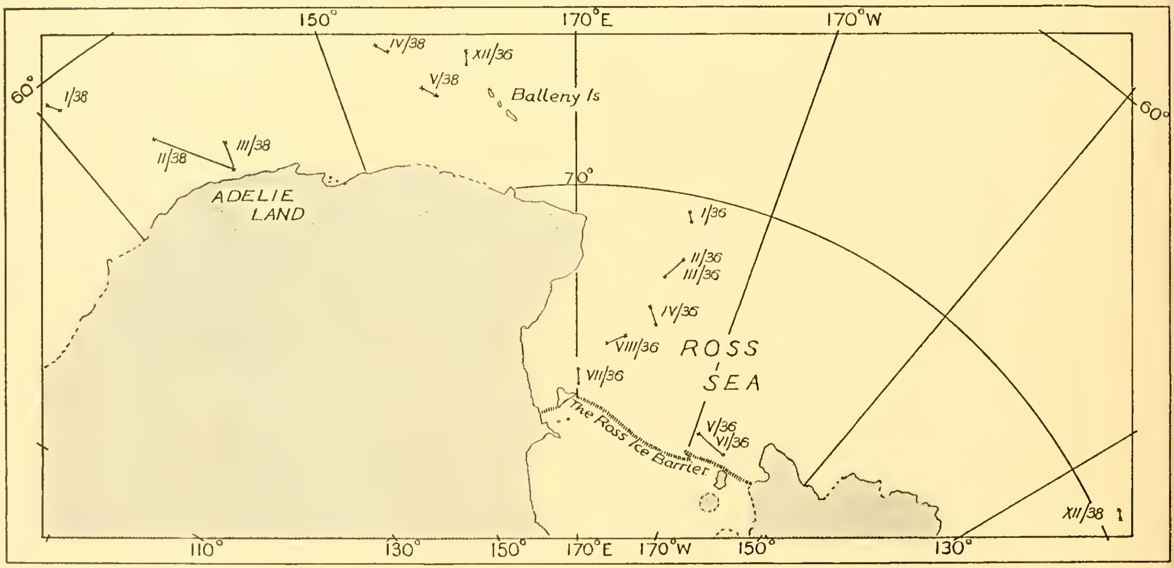


Fig. 1 (*b*).

Fig. 1. Oceanic soundings. Positions between which continuous soundings were obtained with the 'Acadia' recorder. (*a*) Near the Falkland Islands, across the Burdwood Bank and off the western entrance to the Magellan Strait. (*b*) In the Ross Sea, approaching and leaving the vicinity of Adélie Land, and north-west of the Balleny Islands.

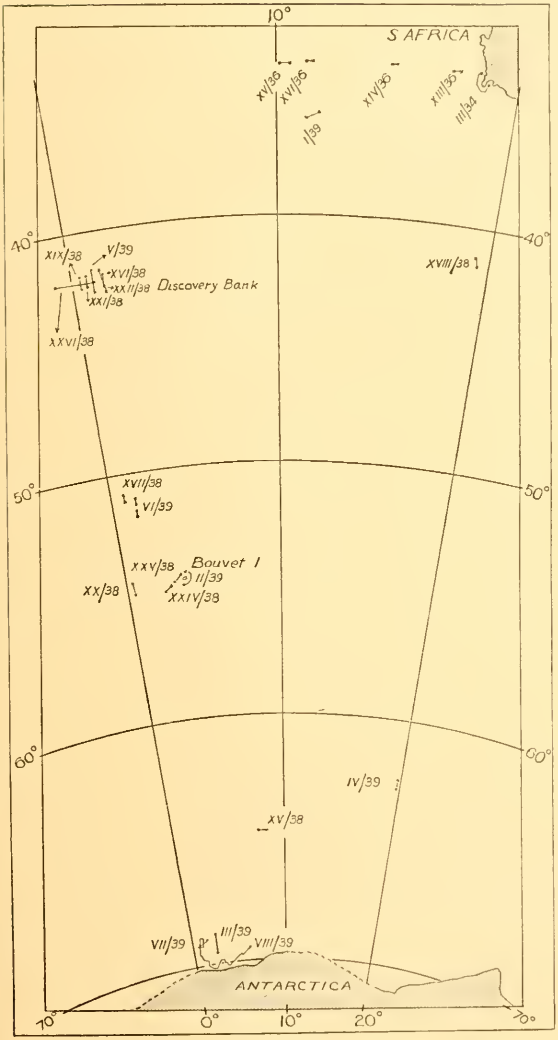


Fig. 2(*a*).

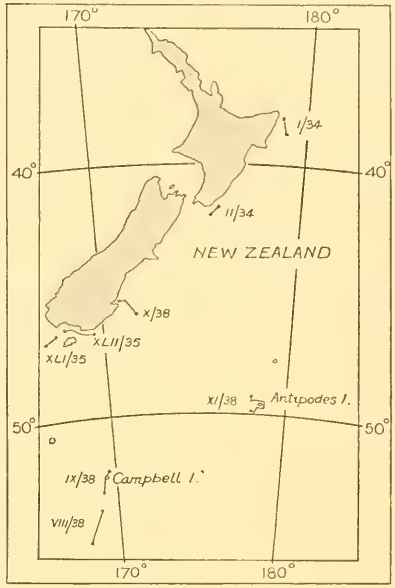


Fig. 2(*b*).

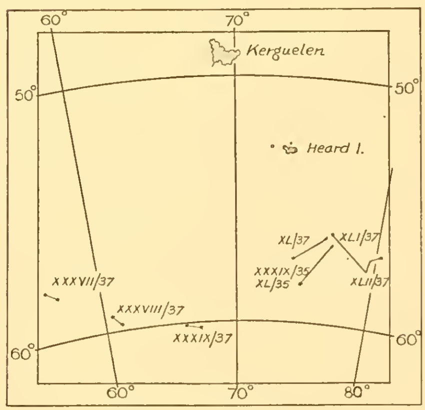


Fig. 2(*c*).

Fig. 2. Oceanic soundings. Positions between which continuous soundings were obtained with the 'Acadia' recorder. (*a*) In the area covered by the repeated cruises south and west of South Africa. (*b*) Off New Zealand and in surrounding waters. (*c*) Across the Kerguelen-Gaussberg ridge.

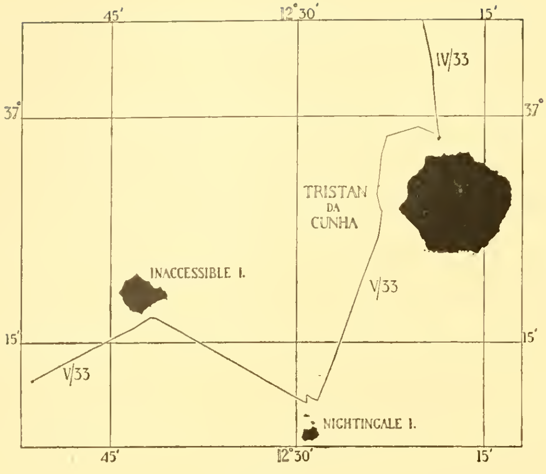


Fig. 3 (*a*).

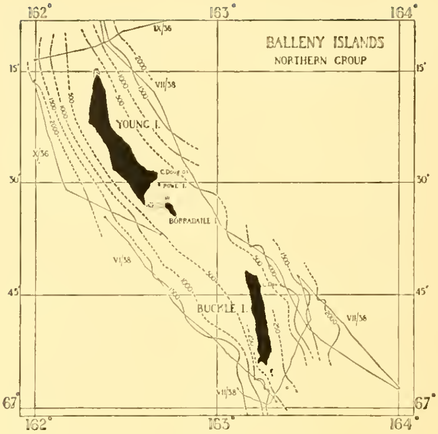


Fig. 3 (*b*).

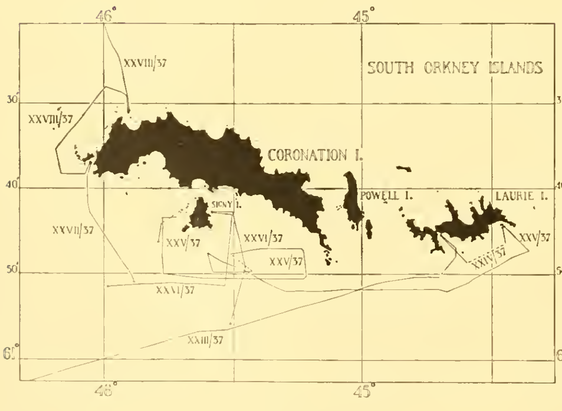


Fig. 3 (*c*).

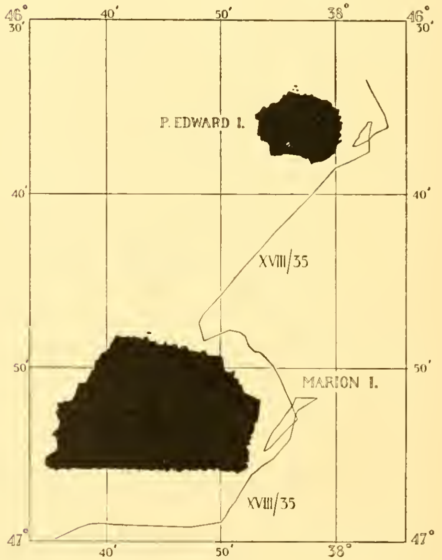


Fig. 3 (*d*).

Fig. 3. Soundings during hydrographical surveys: continuous records. (*a*) Tristan da Cunha group: approaching Falmouth Bay, Tristan da Cunha, and from thence to Nightingale and Inaccessible Islands. (*b*) Balleny Islands: running surveys of 1936 and 1938, together with contours. (*c*) South Orkney Islands: completion, in 1937, of the earlier running survey of 1933. (*d*) Marion and Prince Edward Islands: 10 hr. continuous recording during an examination of these islands in 1935.

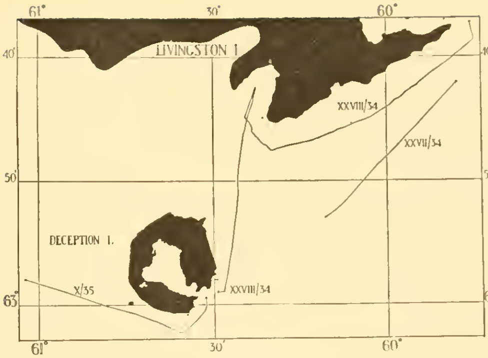


Fig. 4(*a*).

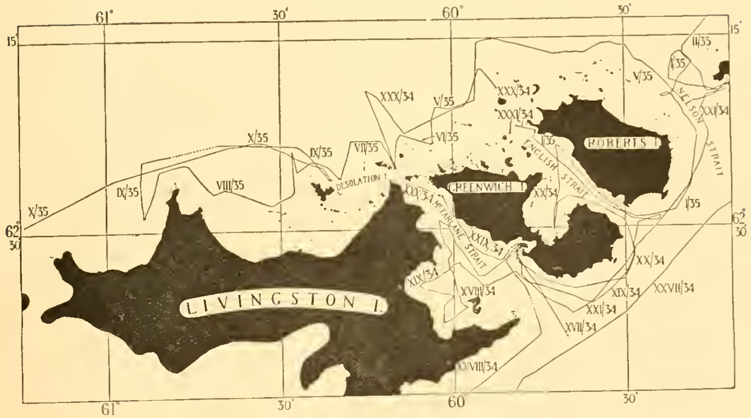


Fig. 4(*b*).

Fig. 4(*c*).

Fig. 4. Soundings during hydrographical surveys: continuous records. (*a*) Deception and Livingston Islands: recordings made during the running survey of the South Shetlands in 1934–5. (*b*) Livingston, Greenwich and Roberts Islands: recordings made during the running survey of the South Shetlands in 1934–5. (*c*) Nelson and King George Islands: recordings made during the running survey of the South Shetlands in 1934–5 and 1936–7.

CORRECTION OF ECHO SOUNDINGS

As was stated in our earlier report, echo sounding saves a tremendous amount of time, and at moderate or great depths it is more accurate than sounding by wire. The tables compiled for the Hydrographic Department by Matthews for correcting the speed of sound in sea water have been much amplified since our previous report, as a result of the acquisition of considerably more hydrological data, and the new edition of 1939 contains a more accurate delineation of the increased number of areas for which correction tables are now available. As this new information was not available for use on board the 'Discovery II' before the end of her last commission it has been of interest to note that the original tables in use on board, most of which had been compiled from our own hydrological observations, by the methods shown in the first edition (1927) of Matthews's tables, vary only slightly from the more recent publication. The difference after correction by the new tables is in most instances so small (usually not more than 1 or 2 fm. in 2500 fm.) that it has not been considered worth while to re-calculate the many thousands of soundings involved, especially as an error of 1, 2 or even more fathoms may easily occur, either in reading off the soundings direct from the recorders or from the method used for timing the echo of the old 'listening' receiver. In the latter instance it was not possible at the greater depths to read to a greater degree of accuracy than $\pm 0{\cdot}005$ sec.—equivalent approximately to an error of ± 2 fm. This accuracy, however, was difficult to attain and it is probable that the minimum error was more nearly ± 4 fm. Since the accuracy of the soundings also depended greatly on the speed of the machines or recorders, periodic checks were made with an accurate stopwatch, and a rating error noted if the speed was greater or less than the normal. An error, however, which was difficult or almost impossible to detect arose in reading off the depths from the recorders. This reading off can be done in two ways: (*a*) The depths can be read directly off the wet paper as it passes the scale on the recorder, or (*b*) the paper can be dried and the soundings read off at any time afterwards with a special scale for the dry paper. Each method has its advantages but it was our practice to use method (*a*) and enter the soundings in a special log-book. This enabled a complete check to be kept on the exact time of the sounding, since the minute markings on the records could be compared with a chronometer watch, and had the added advantage that an operator was always present when survey work was in progress, to report any sudden irregularity or approaching danger. Method (*b*) on the other hand did not require such a constant watch to be kept on the recorders, but had the serious disadvantage in the 'Acadia' recorder that whether the paper was dried artificially by the heater incorporated in the lower part of the tank face, or was allowed to dry naturally away from a strong light, the shrinkage of the paper on drying was not always even. This was especially so when the paper was dried artificially, and as a final check on the soundings was always required when they were used for survey work, the heater was disconnected and the paper allowed to dry naturally before storing. Even then there was the disadvantage that the final width of the dried paper might not always be exactly the same, on account of the varying humidity and temperature of the air.

When soundings are being obtained on moderate or steep slopes it is, theoretically, possible to correct for the errors thus set up. In practice, however, the problem is one of great complexity, and will be discussed at length later in this report. It is sufficient here to say that in general it has not been considered practicable to correct our soundings for slope error.

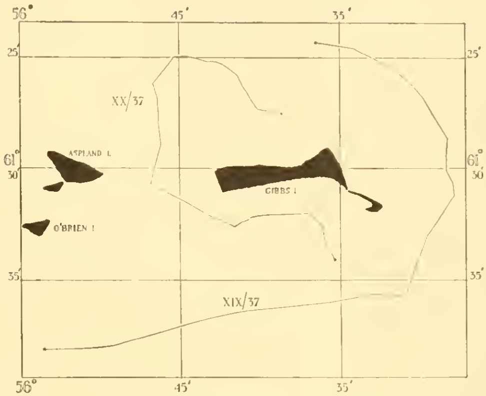


Fig. 5(*a*).

Fig. 5(*b*).

Fig. 5. Soundings during hydrographical and other surveys: Continuous records. (*a*) Aspland and Gibbs Islands: recordings made during a running survey in 1937. (*b*) South Georgia and vicinity: various recordings made between 1933 and 1938.

DIFFICULTIES OF OBTAINING SOUNDINGS IN BAD WEATHER AND IN CERTAIN PARTS OF THE OCEANS

As a general rule the strength of the echo is inversely proportional to the depth of the water, but the echo is very much affected also by the physical condition of the water and the nature of the bottom, and it is specially important that the various causes of weak or inaudible echoes should be distinguished so far as they are known. Weak echoes can be caused by defects in the sounding set, and in the earlier years of our work it was assumed that weak echoes were generally attributable to such mechanical defects. During the later voyages of the 'Discovery II', however, it was found that difficulties in obtaining soundings could usually be traced to one or more of the following external causes: water noises, aeration, layering of the water, a soft or badly reflecting bottom, or an irregular bottom.

In bad weather the echo is liable to be obscured by a background of water noise associated with the ship's progress, and this may necessitate slowing down or heaving-to while sounding. In deep water, however, the echo strength was usually impaired during a gale, and this weakening often persisted for more than 24 hours after a severe gale had ceased and the water-noise background had subsided. This effect is probably due to the persistence of aeration in the surface water with consequent blanketing of transmission and echo. Such conditions rendered it difficult to obtain soundings in deep water even with the ship stopped.

Conclusive evidence that aeration can impede, or indeed completely cut off, the passage of supersonic sound in water was obtained on occasions when the ship's engine was put astern after letting-go an anchor. This sets up considerable local aeration, especially in shallow water, and when the ship moved over this patch of aerated water the echo trace on the M/S XIID recorder completely disappeared, returning only when the turbulence and aeration had subsided. With the deep-sea sonic set the strength of the signal appears to have been sufficient to overcome this local shallow area of aeration in depths of less than 50 fm. (91 m.).

Difficulty in obtaining an echo was also noticed on many occasions in certain latitudes even when weather conditions were such that perfect or almost perfect reception was to be expected. This applies especially to the neighbourhood of the Antarctic Convergence. The Convergence (see Deacon, 1937, and Mackintosh, 1946) is continuous round the Southern Ocean, and may be described simply as the line at which the Antarctic surface water sinks below the less dense sub-Antarctic water. In lines of soundings running for instance southwards it was usually found that the echo failed just north of the Convergence, especially where the latter was well defined, and was commonly very weak for a hundred or more miles to the south of it, even when it was ill defined. Deacon draws attention to the area of mixed water which lies just north of the Convergence and it is in this area that echoes become weak or have, on a few occasions, disappeared entirely. Further reference to Deacon (figs. 12, 13) shows that north of the Antarctic Convergence the discontinuity layers are well marked and have a pronounced horizontal or oblique trend. It is thus extremely probable that not only is the greater proportion of the outgoing soundwaves deflected by these layers of differing densities, but that the echoes from any soundwaves which may have penetrated in a direct line to the bottom are themselves deflected on their upward journey. Text-fig. 6, which is a section showing the vertical distribution of density in terms of σ_t, is a good example of these conditions which prevailed on the Greenwich meridian in February 1939, in positions where we noted a distinctly weaker echo. This diagram has been prepared for me by Mr A. J. Clowes and will eventually form part of a further report on the hydrology of the Southern Ocean.

It would appear that the weak echoes obtained to the south of the Convergence are attributable to the composition of the bottom deposit. A bottom of rock or hard clay will return a strong, clear echo,

but soft ooze will often fail to return more than a faint whisper, which only an operator with much experience can distinguish from other noises. The strength of the signal returning from a hard or rock bottom has often been sufficient to cause re-echoes, and many have been recorded from quite considerable depths. In one instance, on 8 March 1938, at St. 2277 (65° 19·6′ S, 81° 42′ W) a clear re-echo was heard at twice the observed depth of 2428 fm. (4440 m.). If the soundwave is of sufficient strength to echo again between the hull of the ship and the bottom at this depth, and then provide a clearly audible signal on its second return, it would appear that there should be ample reserve of power to provide an echo even from a moderately soft bottom. Immediately south of the Convergence, however, the deposit is almost pure diatom ooze and it apparently lies on the bottom as a very soft covering, the upper part of which is flocculent and comparable to a very thick soup. At St. 2519, in 51° 57·8′ S, 19° 32′ E, the bottom reversing water bottle of the deep hoist apparently hit bottom and brought up an excellent sample of this liquid ooze from 2865 m. (1567 fm.).

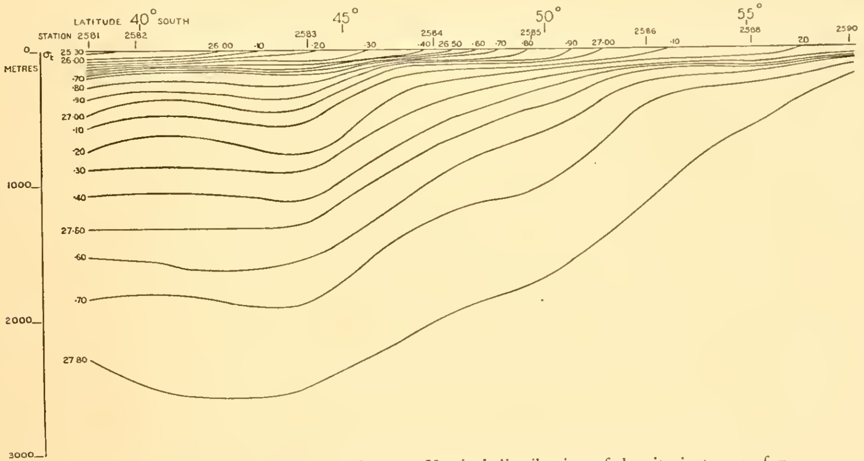


Fig. 6. 0° Line, February–March 1939. Vertical distribution of density in terms of σ_t. Antarctic Convergence in, approximately, latitude 49° 33′ S.

Generally, it may now be said that a belt of diatom ooze surrounds the globe in the southern hemisphere and that its northern limit approximates closely to the northern limit of the Antarctic Convergence (see Hart, 1934, pp. 185–6 and Deacon, 1945, pp. 11–20). We thus find in the neighbourhood of the Antarctic Convergence that there may be two important factors which will cause weak echoes, i.e. the horizontal trend of the discontinuity layers north of the line of the Convergence, and the bottom deposit of diatom ooze to the south. For a short distance north of the Convergence, when that line is displaced to its southern limit, it is therefore possible to have both factors, and under these circumstances sonic soundings have been proved to be almost impossible to obtain. It seems probable, however, that supersonic methods might be more satisfactory, as it is possible to obtain a better concentration of the beam of soundwaves. The belt of diatom ooze eventually fades out to the south into a belt of glacial mud from which it is possible again to hear a clear echo.

An area with faint or no echoes was also found by the second Byrd Antarctic Expedition, when their ship the 'Bear of Oakland' was on passage between New Zealand and the Ross Sea; though the latitude in which they were puzzled by the faintness of the echoes was south of any position in which we found the echo regularly to disappear or become very faint. Roos (1937, p. 582), in commenting on this occurrence, suggests that it might be due to a very soft bottom or to heavy rolling which, by

producing an excessive angle between the ocean floor and the face of the hydrophone tank, made the incoming echo less audible. The former explanation seems the more probable, for heavy rolling may take place anywhere in the Southern Ocean, and it was certainly not the cause of the faint echoes found by the 'Discovery II' near the Convergence, for, as mentioned above, the rolling could always be remedied by manœuvring the ship to suit the weather.

Another local area in which only weak echoes were received was found by the 'Discovery II' on the Greenwich meridian, south of the region of diatom ooze. It lay roughly between 54° S and 60° S and from the number of soundings which we eventually obtained during a series of repeated cruises in that area it seems likely that an extremely irregular bottom was the cause of our weak echoes. Rapid changes in depth were experienced and on one occasion the depth shoaled by nearly 2000 m. (1094 fm.) in 30 min., with the ship proceeding at normal speed. Changes of depth nearly of this magnitude were by no means uncommon, and attempts to take a record of some of the slopes with the 'Acadia' recorder were not very successful. On some occasions, indeed, the depth altered so rapidly that it was impossible to get an accurate reading even on the old 'listening' receiver. This problem of echoes from steep slopes will be considered in more detail in the next section of this report; but it may be stated here that owing to the extreme irregularity of the bottom now known to exist in many areas of the Southern Ocean, it seems probable that the weakness of echo strength reported often from south of the Antarctic Convergence-ooze area is more than likely to be due to this cause.

SLOPE CORRECTION AND THE CONDITION OF THE OCEAN FLOOR

In general it appears to have been accepted that the soundwaves transmitted by sonic echo-sounding apparatus are reflected from the bottom at the point nearest the ship. If this is established, then with a level bottom, the depth recorded is the true depth at that point, but if the sea bed is sloping or comprises irregular features then the echo depth obtained is not the true depth and will require a correction for the angle of the slope. This correction is, of course, in addition to the normal corrections for draught and the speed of sound in sea water in different areas. In discussing the question of slope correction for sonic soundings, therefore, it is assumed that the expression 'echo distance' is the recorded depth which has been corrected for the speed of sound, etc., and that, unless otherwise mentioned, the soundwaves are reflected from the nearest point of the bottom.

The various methods of correction for slope have already been described at length in the *Hydrographic Review*, and Shalowitz (1930), Vanssay de Blavous (1930, 1933) and Hayes (1933) are some of the most recent contributors to this subject. Briefly it may be stated here that either the echo distance must be corrected for the slope of the bottom, or the position of the sounding must be moved up the slope until the actual depth at the new position equals the echo distance actually recorded. In a third method corrections embodying both the above systems can be applied. Text-fig. 7 is a simple diagram to illustrate the first two methods, and it will easily be seen that if A is the position at which the sounding is taken then either the echo distance AB must be corrected for slope by a plus correction to give the actual depth AC; or the position of the sounding must be moved from A to A' so that the echo distance AB equals the actual depth $A'C'$. In this figure it is assumed that the slope of the bottom is regular; if it is not then the angle of slope must be determined for the point of observation and the correct echo distance or displacement calculated accordingly.

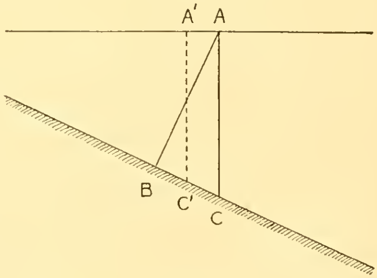


Fig. 7. Diagram to illustrate the theory of slope correction.

In general the angle of a slope can be determined approximately by plotting the series of echo distances obtained, at right angles to the contour lines, and measuring the angle of slope with a protractor.

In practice the echo distance can usually be assumed to be the actual sounding since, from the navigational point of view, the primary object is to establish the ship's position when making a landfall. Normally this implies fixing the ship's position with regard to the continental shelf, or charting her approach to shallow water from deep and vice versa, and there are few slopes where the correction for slope is sufficiently large to be shown on charts constructed on the scales usual for navigational purposes. In shallow water the correction becomes negligible. It should also be remembered that if soundwaves are reflected from the nearest point of the bottom, a ship approaching shoal water will obtain soundings from a position fairly well ahead if the slope is steep or moderately so. This is of distinct advantage to the navigator.

In the 'Discovery II' soundings were normally taken at intervals of one hour (or approximately 9 miles) and in these circumstances an accurate correction for slope is not possible. In the open ocean, however, the bottom is comparatively level and, even with soundings closely spaced, correction for slope is negligible unless the rise is greater than 1 in 10. When a ridge or bank was being crossed, however, we endeavoured to get as many soundings as possible, and, if the weather was favourable, to obtain a continuous record with the 'Acadia' recorder. Correction for slope then became possible, but it must be remembered that considerable errors may occur in fixing a ship's position in mid-ocean; in the most favourable circumstances it is doubtful whether accuracy can be greater than $\pm\frac{1}{4}$ mile, and it is probable that the error is of the order $\pm\frac{1}{2}$ to 1 mile. This fact, together with the necessity for plotting oceanic soundings on charts of a relatively small scale, makes it doubtful whether a correction for slope, either by displacement of position or by an addition to the echo distance, is practicable. It should be realized that a four-figure sounding, plotted on an oceanic chart of the usual scale and on Mercator's Projection, may cover an area of as much as 40–50 sq. miles in the latitude of 60° S and that this area increases to 100–120 sq. miles at the Equator. Thus it may not be possible to plot more than a very small fraction of the soundings from a bank or ridge, and from the navigational point of view correction for slope in oceanic waters is therefore of no value. To the geologist and geophysicist, however, the correct outlines of a ridge may be of definite use, but it remains doubtful whether correction for slope would greatly affect hydrological calculations on upwelling and the movements of the water masses.

The form of the beam of sound projected by the transmitter of a sonic echo-sounding set is of considerable importance in the interpretation of the soundings. It must be assumed that it is in the form of a cone in which the energy is at a maximum along the axis and fades out at the periphery. The amount of 'spread' or dispersal should vary inversely with the frequency of the soundwaves.

It is clear that an allowance must be made for a certain amount of spread. Hayes (1933, p. 154) states that with a relatively high-frequency sonic transmitter (presumably at 2000 cyc./sec.) the diameter of the beam at 2000 fm. (3758 m.) will be 1 mile. This is equivalent to an angle of spread of 14° and, presumably, is the limit of transmission of soundwaves of significant strength. Furthermore, the multiple echoes picked up on the recorder (see p. 56) must be attributed to echoes received from different directions. On the other hand, echoes were obtained from depths of more than 4000 fm. (7515 m.), and re-echoes from lesser depths; and this could hardly be expected were it not that the maximum sound energy is transmitted along the axis of the cone.

Some indication of the limit of dispersal of relatively high-frequency sonic transmissions is perhaps afforded by a sounding record obtained on one occasion when the anchor was being hove-up from 40 fm. (73 m.). The record showed a strong echo from the bottom and, as is natural with a small

object, a faint echo from the anchor. This echo, however, disappeared when the angle of the transmitter to the anchor was 48°, and a limit of spread of the soundwaves of significant strength might thus be indicated.

Difficulties in obtaining echoes from steep slopes may be due to the limited spread of the beam or to scattering, dispersal or absorption of the echo owing to the irregular form of the bottom which often prevails at moderate depths.

Before the advent of echo sounding deep-sea soundings were normally spaced some considerable distance apart and profiles drawn from these observations differ considerably from those constructed from lines of echo soundings at fairly close intervals. A good example of this is given by Sverdrup, Johnson & Fleming (1942, p. 18) where a profile including South Georgia and the South Sandwich Trench is shown, first as based on 13 existing wire soundings and then as constructed from 1300 echo soundings made by the German research ship 'Meteor' in 1926.[1] Our results are comparable to these, and in 1938–9, when a series of cruises was made between the latitude of 40° S and the ice-edge, on the Greenwich meridian, the profiles drawn for each cruise varied considerably, although the tracks were often within a few miles of each other. Two of these profiles are shown in Text-fig. 8 and for the latitudes between which they are comparable (i.e. 45–55° S) the tracks were within 3 miles of each other. From these it will be seen that although the main characteristics are similar, there is a considerable divergence in detail. These profiles, however, are again relatively simple when compared with the continuous records representing soundings every $2\frac{1}{2}$ sec., and although the latter do not cover a large area, they show a degree of irregularity in the sea bottom, especially to seaward of the continental shelf around Antarctica, which makes correction for slope quite impracticable. A section of such a record, which is typical of the sea bed in the neighbourhood of the Scotia Arc, is shown in Pl. XXVII, fig. 1. It was taken in waters of approximately 125–340 fm. (229–622 m.) in the Palmer Archipelago, off Graham Land, but in the interpretation of this it must be remembered that the vertical scale is much exaggerated, and that, since the paper feeds through the recorder at a fixed rate, the degree of exaggeration is dependent on the speed of the ship. To obtain the exact amount of exaggeration the speed of the ship (in knots) should be multiplied by 1·08. In this instance the speed was 9 knots and hence the vertical scale is magnified 9·72 times. Records taken on the Kerguelen-Gaussberg ridge and other such localities in the Southern Ocean show similar though less well-marked irregular features.

Apart from these irregularities in the bottom there are, of course, the difficulties previously mentioned in fixing the ship's position, and thus it has not been considered generally possible to correct our soundings for slope. In certain isolated instances, however, this correction was possible, as for instance when the ship's position could be accurately fixed from bearings on land which she was approaching almost directly up a slope. Such an instance was our approach to Tristan da Cunha in 1933 (Pl. XXVI, fig. 2), and in Text-fig. 9 is shown the profile of the slope drawn to true scale, together with the profile after correction for slope error. It is thought that on this occasion the ship's course towards the land was nearly enough at 90° to the bottom contours to justify slope correction, though this cannot usually be assumed without an adequate survey of the bottom.[2] As can be seen from the figure the correction is of little value for navigational purposes.

So far it has been assumed that echoes are only being received from one point on the bottom, but

[1] We are not fully in agreement with this method of presenting a section of the ocean bed with such an exaggerated vertical scale, since it tends to give a false impression of the relief of the ocean floor.

[2] In 1937 the International Hydrographic Bureau at Monaco circulated a questionnaire which, among other queries, asked the Hydrographic Departments of their member states whether their echo soundings were corrected for slope before insertion on the charts. From the replies received it appeared that very few countries applied slope correction and that many considered the practical error far to outweigh the advantages of such a correction.

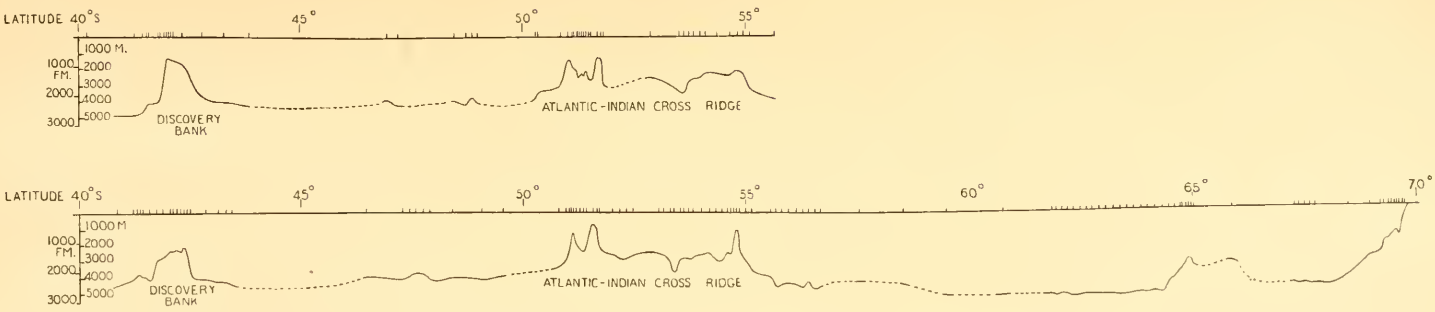


Fig. 8. Profiles of the bottom constructed from soundings taken during two of the repeated cruises on the 0° line of stations in 1938–9. Between the latitudes of 40° and 55° S the maximum difference in longitude was 3 miles. Vertical scale, ×40. Positions of soundings are marked on the horizontal scale.

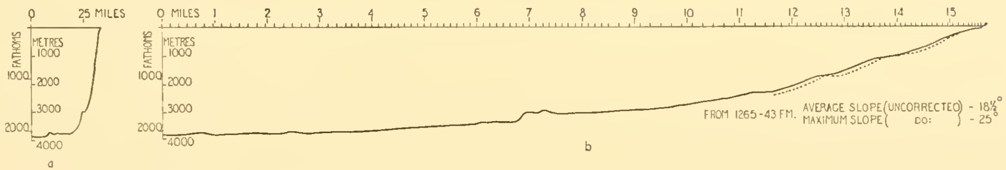


Fig. 9. Slope of bottom approaching Tristan da Cunha from the north. Positions of soundings are marked on the horizontal scales. (*a*) Vertical scale, ×25. (*b*) True scale, based on 116 depths in a distance of 15·5 miles. Dotted line shows true line of bottom after correction of soundings for slope error.

in view of the diverse character of the sea bed, as revealed by the automatic recorder, and the assumed spread of the soundwaves from the transmitter, it appears obvious that echoes may be received simultaneously from more than one point. A large number of records from the 'Discovery II' show such multiple traces (see Pls. XXVII–XXIX), and it will be obvious that this 'third dimension' introduces further complications in the interpretation of the records. It would appear impossible, except in certain isolated instances, to determine the relative positions of the points from which the echoes are being received, since with the conical spread of the transmissions these multiple echoes may be from points on the bottom ahead, astern, or on either beam of the ship. The few exceptions are the records which only show two traces and which probably result from crossing a simple but well-defined narrow valley or depression. As shown in Pl. XXX, fig. 4, these traces appear on the record in the form of 'crossovers'.

If it is assumed that the echo returns from the nearest point on the bottom, then a ship crossing a depression of the form shown in Text-fig. 10*a* will receive echoes at A from A_1, at C from C_1, and at B from both B_1 and B_2. It is probable (and is assumed here) that only one echo would be distinguishable

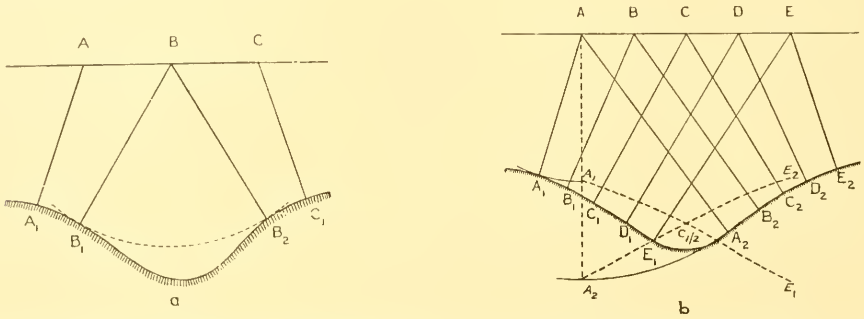


Fig. 10. Diagrammatic representations of sounding across a narrow valley. (*a*) Transmission and echo assumed to be narrow parallel beams. (*b*) Transmission spreading, and two echoes being recorded as in actual practice.

as such with the 'listening' gear, and it follows that echoes from the deepest part of the depression would be missed, and the profile of the bottom could only be assumed to take the form represented by the dotted line. The recorder however is more selective and sensitive than the human ear and it can distinguish echoes from points at different distances. It seems very probable that the 'simple crossover' of the kind shown in Pl. XXX, fig. 4, is in fact the result of crossing a depression of the type shown in Text-figs. 10*a* and *b*. That is to say the 'crossover' is not a precise representation of the actual profile of the bottom but almost certainly represents echoes received simultaneously from both sides of a depression. In Text-fig. 10*b* positions A, B, C, D and E are presumed to be equally spaced points on the ship's track. It must be remembered that in practice continuous soundings are being taken between these points, but the points shown are sufficient to illustrate our theory. At position A echoes are being recorded from A_1 and A_2, the latter being weak. At C the echo strength from C_1 and C_2 is nearly equal and at E the signal being received from E_1 is now the secondary trace and will probably be of just sufficient strength to give a recording under good conditions. From this it will be seen that a rounded, or U-shaped, depression may be recorded as a V-shaped 'crossover' as represented by the pecked lines in Text-fig. 10*b*, and that analysis of such a 'crossover' may give a more accurate representation of the shape of a depression on the bottom than can be obtained by the 'listening' gear.

It should perhaps be pointed out that these 'crossovers', or simultaneous echoes from a valley, can only be recorded when the two echo distances are within the range covered by the width of the record paper which, in our recorder, was equivalent to a depth of 250 fm. (457 m.). If the difference is outside these limits, 'phasing' to bring the second echo on the record will only result in the loss of the one originally being recorded. Normally the differences in echo distances at a 'crossover' are small and it is seldom that they exceed 150 fm. (274 m.). The average, for uncomplicated records, appears to be from 50 to 100 fm. (91–183 m.) but many of them fade out within smaller limits. It seems probable, therefore, that the simple 'crossover' effect is obtained only when crossing a fairly shallow depression or valley, which at the same time is comparatively narrow. It would seem also that the absence of a secondary echo from a wider valley at moderate depths is further evidence of a possible limit to the spread of soundwaves from a sonic transmitter.

In oceanic sounding with the recorder, multiple traces do not appear on the record from depths much greater than 2000 fm. (3658 m.) and are seldom recorded from shallow water of less than 100 fm. (183 m.), or from the continental shelf. On the other hand, records from various depths between 2000 and 3000 fm. (3658–5486 m.) mostly show the bottom as a flat plain; it is in the depths between 1000 and 2000 fm. (1829–3658 m.) that the greatest variety of bottom in the Southern Ocean is met. These really interesting regions are mostly in mid-ocean and on known but ill-defined ridges, but owing to the great irregularity of the bottom echoes are faint and difficult to record except in very fine weather—a condition which is not normally satisfied in these parts—and thus we have not been able to obtain more than a few good records. It is on these records, however, that the greatest number of multiple traces is to be found (see Pl. XXIX, fig. 1), and it is probable that the failure to obtain good results is for the most part due to the very steep slopes and to a diversity of features which causes scattering of transmissions and echoes. Limitation in the angle of spread of the transmissions may be a contributory cause when a slope is very steep and comparatively simple.

Soundings are not always difficult at intermediate depths, and some good records were obtained by the 'Discovery II' on the Antarctic continental slope, especially on the Greenwich meridian in March 1939 (Pl. XXVI, fig. 3). Here the slope is peculiarly free from complexities, and it is further discussed in a later section (pp. 86 to 88).

In the waters adjacent to the Scotia Arc an exception is found to the general rule that multiple traces are not usually recorded from depths of less than 100 fm. (183 m.). Areas such as the continental shelf around South America and the Falkland Islands, the Burdwood Bank, the approaches to South Africa, Australia and New Zealand, and other shallow areas show, on the whole, a remarkably level bottom sloping up gently towards the land. In the shallow water off the Scotia Arc conditions are quite different, and the bottom is extremely varied, though perhaps not quite so irregular as in the slopes at intermediate depths. 'Crossovers' on sonic records are common but are of small extent, and there are very many steep slopes. Instances, however, of more than two traces from these shallower depths are rare.[1] An example of this very varied bottom from the Palmer Archipelago has already been mentioned (see p. 54 and Pl. XXVII, fig. 1), and more will be given when the running surveys of the South Shetland Islands are dealt with (pp. 79 to 81).

[1] A possible explanation of the absence of multiple traces on records from waters of less than 200 fm. (366 m.) in depth here may be that the spread of the transmission at this depth is not sufficient for echoes to be recorded from other than the nearest point of the bottom. It is probable that the bottom is no less varied than that of the intermediate depths between 200 and 2000 fm. (366 and 3658 m.) but at these greater ranges the spread in the transmission will allow features which are not directly below the ship to be recorded.

COMPOSITION OF THE BOTTOM

It is an established fact that the composition of the sea bed has an appreciable effect on the strength of the echo. We have already mentioned the difficulty of obtaining soundings in deep water in certain regions where the bottom is very soft, but with a hard bottom re-echoes can often be obtained down to moderately great depths. An instance of this has also been quoted (p. 51) and there were many other occasions when re-echoes were obtained from lesser depths. In deep water the automatic recorder cannot record both echo and re-echo unless, by chance, the re-echo falls in the same phase as the first echo, i.e. an echo from, say, 1050 fm. (1920 m.) and a re-echo at 2100 fm. (3840 m.) will fall in the phases 1000–1200 fm. (0–200 fm. on the phasing dial) and so be recorded simultaneously on the paper. An example of this from soundings of 890 to 1000 fm. (1628 to 1829 m.) is shown in Pl. XXX, fig. 2. On the other hand an echo from, say, 1275 fm. would be picked up in the 200–400 fm. phase, and its re-echo at 2550 fm. in the 400–600 fm. phase. In shallow water of 50 fm. (91 m.) or less, with a bottom of rock or hard sand, as many as four re-echoes have been recorded with sonic transmissions. Similar records have been obtained in shallow water with the M/S XII D recorder, though with the supersonic transmissions the number of re-echoes does not appear to be so great. The reason for this is almost certainly that the faces of both the deep-sea transmitter and hydrophone were exposed to the sea, whereas the supersonic transmitting and receiving tanks were secured *inside* the hull plating, which at this point was 1 in. in thickness.

For some years it has been known that supersonic transmissions in very shallow water could detect an overlay of mud, silt or sand on rock. Records from many parts of the world have been obtained with Messrs Henry Hughes and Son's machines, with the British Admiralty system of transmission, but references to these in the meagre literature on echo sounding in this country appear to be scarce. Among the few illustrations traced are portions of two very good records taken respectively in Canada (Lake St Peter, Quebec) and Denmark (Aarhus). Portions of these records were published in Messrs Hughes' private journal, *The Husun Review* (1936), but the reproduction is not sufficiently clear to show the depths at which they were taken. It appears fairly obvious, however, that they were in very shallow water. Another series, but with the depth scale clearly marked, shows overlays at 5–18 m. (3 to 10 fm.), and forms the illustrations to a report on the survey of Lake Windermere in 1937 by Mortimer & Worthington (1940). Chapman (1944) has shown echo-sounding records taken in water of depths up to 10 fm. (18 m.). These were taken during a survey of the British Coasts, primarily to determine the extent of the beds of the seaweeds of the genus *Laminaria*, but it might be expected that some indication would be seen of the presence of more than one layer of bottom deposit. Unfortunately from the echo-sounding point of view no depth scale is given, and this, together with the difficulty of reproducing such records clearly, makes it doubtful whether these illustrations are of much value for the determination of the composition of the bottom. Re-echoes are common but in one instance only does there appear any possibility that the soundwaves have penetrated beyond the surface of the bottom, and even this example (Chapman, pl. i, fig. 1) is open to several interpretations. As to work in other countries Th. Stocks (1935) has given an account of experiments in the Baltic, at depths of 11–22 m. (6–12 fm.). The echo-sounding set used here, the Debeg 'Radiolot', differed from the British Admiralty supersonic system in that the oscillation of a system of quartz plates was used as the source of the transmissions, and the returning echoes were observed directly as spots of light on a scale. It is claimed for this sounding set that the angular spread of the beam did not exceed 10°. From the illustration in Stocks' paper (fig. 3) it would appear that multiple spots of light were received, from a single transmission, over a portion of the scale covering a total depth of approximately 4 m. (13 ft.) and commencing at a reading of 15·5 m. (51 ft.). As the normal echo from one transmission,

at a depth of 182 m. (100 fm.), gave a single spot of light on the scale equivalent to a depth of 1·5 m. (5 ft.) these multiple spots have been interpreted as echoes from successive layers of the bottom deposit.

This may be correct, for the greatly increased frequency of the short-wave quartz transmitter (slightly more than twice that of the Admiralty system) may allow of greater penetration, but without the evidence provided by a permanent record there must remain an element of doubt in this assumption.[1] With the British Admiralty system of permanent recording there does not appear to be an instance published of the soundwaves penetrating more than what is apparently a single overlay on a harder bottom. Stocks (1935) and Rust (1935) have pointed out that the correct width of each layer in the deposit could not be accurately assessed, since the velocity of sound in the respective media was certain to show a difference from that determined for sea water. Theoretically this is true, but it is doubtful whether the accuracy in reading off depths from a visual light scale would be in itself sufficient to warrant an exact measurement being given for the extent of each layer. In practice it is doubtful whether a change in velocity would have much effect even on the measurements obtained by permanent recording at the very shallow depths mentioned, and it is probably true to say that the measurements of the extent of an overlay, obtained from a permanent record, would not be far from the actual figures. Confirmation of this could only be obtained from cores of the bottom deposit taken at the time when the soundings are recorded.

Rust (1935) mentions that layering in the bottom sedimentation has been detected with sonic transmissions but he does not give any particulars. No account of any such occurrence appears to have been published in this country but it is known[2] that in 1935 H.M. Survey Ship 'Challenger' obtained an excellent record of mud overlying rock near Trinidad, in the West Indies. The echo-sounding set used was the ordinary Admiralty pattern sonic set for shallow water, but with the addition of a recorder. The depth of water over the mud varied between 90 and 100 fm. (165 and 183 m.) and the depth of the mud itself from 180 to 240 ft. (55 to 73 m.). The record, unfortunately, was not retained after the completion of the survey. A careful examination of the many records we possess from the 'Acadia' recorder fails to show any such definite evidence that the soundwaves penetrated the bottom deposit. Admittedly, the great majority of these records were made in depths of water much beyond the range at which layering has hitherto been detected with supersonic equipment; but with the sonic transmitter and hydrophone both exposed to the sea it had been thought that if as many as four re-echoes could be recorded from shallow water, then there was a reasonable chance of the sound penetrating beyond the immediate surface of the bottom. The attenuation of the soundwaves from the deep-sea transmitter, however, was very great, and as can be seen from some of the records shown in Pls. XXVI–XXX the echo marking which thus results from a normal echo may easily cover any trace of an echo from a harder layer below the surface of the bottom. Among the records which were closely examined are certain peculiar recordings of fairly flat bottoms which might be considered as evidence of layering. The spread of sonic transmissions, however, is such that these secondary traces may well have their origin in other features of the bottom, at depths of more than 100 fm. (183 m.), and although there remains an element of doubt in some instances, these records have generally thus been interpreted.

We have been equally disappointed in such few records as remain from the M/S XII D recorder. The great majority of these have faded (see Appendix I, p. 97) and although the contour of the bottom was pencilled or inked-in shortly after the record was dry (see Plate XXXI, fig. 2), little else remains, except

[1] Conversations with the Marconi International Marine Co., Ltd., confirm our doubts on this point. The Marconi Co. have much experience of visual recording by light in conjunction with a quartz transmitter (or projector) and are not by any means prepared to assume that multiple flashes on the scale are echoes from successive layers of the bottom. In fact, they consider that the presence of such multiple effects (which to them is a well-known occurrence) is more probably caused by attenuation of the reflected soundwaves, owing to a rough or confused bottom.

[2] Private communication to the author.

on some records where there is an indeterminate marking below the lines. On the few that have remained on the whole fairly legible there is no definite evidence of layering, although in one or two instances it is just possible that this has been recorded. Our records, however, were very seldom taken in waters as shallow as those previously mentioned; shallow water to us usually meant depths of 30 to 50 fm. (55–91 m.), and even in enclosed anchorages in the Antarctic, where an overlay of glacial mud could reasonably be expected, we were mostly compelled, from lack of accurate information, to anchor in depths of water varying from 25 to 40 fm. (46–73 m.). In addition it must be remembered that our supersonic transmitter and receiver tanks were mounted inside the hull plating, with a consequent loss of signal strength. In the instance quoted above of the survey of Lake Windermere the transmitter and receiver used were protected only by a thin sheet of metal; for the other records shown in *The Husun Review* nothing is known about the thickness of plating below the tanks. It is probable that the face of the quartz transmitter referred to by Stocks was in contact with the sea, but even if it was protected it is unlikely that such protection was more than a very small fraction of an inch in thickness.

The loss of records through fading may thus be serious, for they cannot now be subjected to a critical examination. Such work can scarcely be done during a running survey, for the logging of soundings, either direct from the recorder or from the dried paper after the day's work, leaves little or no spare time. It is therefore to be hoped that as the result of the experiments now being made, a more permanent marking on the records will be achieved in future.

TERMINOLOGY OF SUBMARINE RELIEF

The need for a systematic nomenclature for the features of the sea bottom became apparent many years ago and the first serious attempt to provide for such a need appears to have been made by Petermann, in 1877. Between then and 1899 Agassiz (1888), Murray (1895) and Supan (1899) contributed greatly to the subject, and in the latter year, at the Seventh International Congress of Geographers in Berlin, consideration was given to certain principles to be applied in naming the features of the sea bottom. These principles were formulated by Krümmel and Mill on a geographical basis and have become the foundation of most of the modern nomenclature. In 1932 Littlehales described the first and second magnitude forms of the ocean bottom together with an appropriate terminology which had by then attained international currency. In the same year the International Hydrographic Bureau published their *Terminology of Submarine Relief*.

In 1936 an International Committee was formed to report on the 'Criteria and Nomenclature of the Major Divisions of the Ocean Bottom', and their findings were published by the Association d'Océanographie Physique (1940). The Committee considered many suggestions, but there is still much confusion over some of the terms which should be applied to the relief of the ocean floor. In the present report we have adhered generally to the terminology of Littlehales for the description of the submarine relief, and for the nomenclature of the different divisions of the sea bed in the southern seas to the terms hitherto generally adopted in the publications of the Discovery Committee. Some of these terms were described by Mackintosh (1940) in his article for the International Committee. We are not, however, altogether in agreement with the use of the term 'swell', which now appears to be fairly widely used as the definition of a rise which separates two deep basins, and which has a saddle depth of 4000 m. or more. The original word proposed by German authorities to define such a feature of the bottom relief was 'Schwelle', of which the literal translation is 'sill', meaning a 'threshold'. It was to be additional to the terms 'ridge' and 'rise', which were already well established. The use of the word 'swell' as the alternative in English to 'Schwelle' may be intended to convey more accurately this conception of a slight rise or swelling of a few hundred metres in the bottom relief at the greater depths, as opposed to a more definite rise of, say, 1000 m.

The terms 'ridge' and 'rise', however, would appear to be sufficiently expressive to provide an adequate description of the bottom relief between the deep basins of the various oceans, but if it is considered really necessary to have this additional term we would then suggest that the word 'sill' is much preferable as the English version of the term 'Schwelle'.

THE SCOTIA ARC (Plate XXIII)[1]

In our previous report on soundings (1932, pp. 214–9) much evidence was presented in support of an arcuate connexion between Tierra del Fuego and Graham Land, by way of Staten Island, the Burdwood Bank, the Shag Rocks, South Georgia, the Clerke Rocks, the South Sandwich Islands, the South Orkney Islands, Elephant and Clarence Islands and the South Shetlands. Such a connexion had long been forecast by some geologists, but evidence from rock specimens was scanty or even contradictory and, prior to the work of the Discovery Committee's ships, very little information was available from soundings.

The term 'Scotia Arc' was adopted on the suggestion of Mr J. M. Wordie (see Herdman, 1932, p. 214) but does not appear to have met with universal approval; Mosby (1940, p. 96), for instance, prefers the term 'South Atlantic Arc' and German authorities, such as Stocks (1937, 1939) and Wüst (1933), have persisted in the view that their term 'South Antilles' is more correct. Reasons have already been given (1932) for preferring the term Scotia Arc to that of the South Antilles and, as the name 'Scotia Sea' is generally accepted for the area around which the major portions of the Arc are grouped, it does not appear that the term South Atlantic Arc is a better alternative. In our opinion this latter name is also slightly misleading, and in this report the name Scotia Arc will be retained.

Between 1932 and 1939 many thousands of additional soundings in this area were taken by the 'Discovery II', and, by landings and dredgings, we have also been able to obtain relevant geological material. Samples of rock were obtained from the South Shetlands, parts of Graham Land and the off-lying islands to the north-west, Gibbs Island (near Clarence Island), and Saunders Island, in the South Sandwich group. Dredged material from near the Shag Rocks, from Clarence Island, and from four stations in the South Sandwich group completed the collection. Although the evidence from the South Sandwich group is inconclusive, Tyrrell's report on these specimens (1945) supports the theory, favoured by Suess and others, of a tectonic connexion between South America and West Antarctica along the Scotia Arc.

Tyrrell considers that the predominant basic lavas of the South Sandwich Islands show a closer affinity with the comparable rocks of the Antilles of North America than with those of the Andes, and he suggests that the South Sandwich Islands may not lie on the main line of the Scotia Arc, but may form an easternmost ridge parallel to and in echelon with it. In support of this he notes the south-eastward trend of the axis of South Georgia, and the northward extension of the 3000 m. contour (shown in pl. xlv of our previous report of 1932) leading down to the South Orkney Islands. Since the publication of that chart, however, further soundings have provided valuable evidence of a far more prominent ridge which appears to connect the South Orkney with the South Sandwich Islands (see pp. 73–4), and there seems little doubt that this represents the main line of the Arc. Unfortunately, we have had no new soundings to the south-east of South Georgia but, in our opinion, those already obtained are of sufficient density to preclude the possibility of a direct connexion between the South Orkneys and South Georgia.

[1] As in our earlier bathymetric chart soundings from sources other than the Discovery Committee's vessels are shown in Pls. XXIII to XXV as open circles. Our soundings up to May 1932 are shown as black dots; subsequent to that date crosses have been used to indicate the positions of 'Discovery' soundings. Since the scale is small it has not been possible to show all the soundings taken when they were closely spaced, or when continuous soundings were being taken with the recorder.

The existence of a continuous ridge between the South Sandwich and South Orkney Islands has been queried by Wüst (1933, pp. 44–5), on account of the percolation of Antarctic-Atlantic water into the 'South Antilles Sea', at a point half-way between the South Sandwich group and the South Orkneys. His facts are deduced from the potential bottom temperatures and in his illustration (pl. ii) he shows a break of approximately 90 miles in the ridge, centred about 34° W, where a depth of more than 2000 m. (1094 fm.) is to be expected. From our line of soundings along this part of the ridge in 1932 it would appear that if such a break does exist in this position then its maximum width must be considerably less than that deduced by Wüst. Our observations show that in the neighbourhood of the longitude in question there can only be a maximum distance of 20 miles over which depths of more than 2000 m. (1094 fm.) can be expected; in fact, the horizontal distance between the 1000 m. (547 fm.) contours is only some 40 miles at this point. It should also be pointed out that, in view of the extremely irregular form of the Arc in general and especially of the known complicated area west of 40° W longitude, it cannot be said that this one line of soundings gives a complete picture of the ridge at the point in question. It is, in fact, very probable that a system of parallel ridges will be found to exist here, similar to those found between Clarence Island and the South Orkneys. Some further observations on this subject have been made by Deacon (1937, p. 111), who shows that from the hydrological point of view the existence of low-bottom temperatures in the Scotia Sea may not necessarily be evidence of an inflow of cold bottom water from the Weddell Sea, but may well be due to the formation of cold bottom water in the deeper regions of the Scotia Sea which lie north and west of the South Orkneys.

Considerably more detail in the delineation of the Scotia Arc has been made possible as the result of the many further soundings taken by us in this area since 1932. The South Sandwich Trench,[1] which is perhaps the outstanding feature of the Arc, was crossed a further seven times between December 1932 and March 1937, and four of these lines of soundings were far to the south of any crossings previously made. We had always suspected that the Trench might extend farther to the south and west than the earlier soundings had shown, and it now seems certain that its south-western limit is not far from a position in 61° S, 26° W, with its line of curvature lying almost parallel to the line of the South Sandwich Islands. At the northern end soundings taken in December 1932, and August 1934, show that the deepest portion of the Trench extends about 60 miles farther west than hitherto determined, and that the 5000 m. contour now lies some 30 miles nearer to South Georgia, extending almost to the 4000 m. contour. The length of the Trench can now be stated with fair accuracy; at depths of more than 5000 m. (2734 fm.) it extends for approximately 650 miles and at depths greater than 7000 m. (3829 fm.) the length is approximately 500 miles. The maximum depth of 8264 m. (4519 fm.) obtained by the 'Meteor' in 1926 was not exceeded but, in December 1932, in 54° 57′ S, 29° 26′ W we obtained a sounding of 8200 m. (4484 fm.), which was 98 m. (179 fm.) in excess of our previous record of 8102 m. (4430 fm.) in 56° 33′ S, 24° 33′ W. In all the seven crossings made since 1932 we obtained fifty-five soundings of more than 5000 m. (2734 fm.) and of these thirty-one were of more than 6000 m. (3282 fm.), thirteen of more than 7000 m. (3829 fm.) and one of more than 8000 m. (4376 fm.). From the evidence now available it appears reasonable to assume that the Trench has a depth considerably in excess of 7000 m. (3829 fm.) for the greater part of its length, though it

[1] It is considered that the name 'South Sandwich Trench', in accordance with Littlehales's terminology, is preferable to 'South Sandwich Deep'. We are not, however, in agreement with the suggestion made by Wüst (1940, p. 20) and others that the deepest known parts of the Trench should be called Meteor Deep and Discovery Deep respectively. Since those soundings of more than 8000 m. were obtained, the 'Discovery II' has obtained a sounding of 8200 m. some 90 miles west of the 'Meteor's' greatest depth and nearly 200 miles distant from the greatest depth previously determined by the 'Discovery II'. A more complete survey of the Trench may well disclose even greater depths, especially if the recorder can be used, and it seems premature to give names to the deepest parts which so far happen to have been found.

will be noticed that at the southern end it narrows considerably. The distance between the 7000 m. contours at the northern end varies between 17 and 30 miles, whereas south of latitude 57° S the Trench gradually narrows from 15 to 4 miles in width between the same contours. It would have been of the greatest interest if continuous soundings could have been taken across the Trench with the recorder, but on no occasion was this possible. Four lines of soundings were run across it after the recorder had been fitted (in 1934 (2), 1936 and 1937), but on the two earlier crossings (a zigzag, or double crossing in April 1934, between the latitudes of 58° S and 59° 31′ S) the instrument was out of action, and on the later crossings, at the extreme northern and southern ends, bad weather precluded records from such great depths.

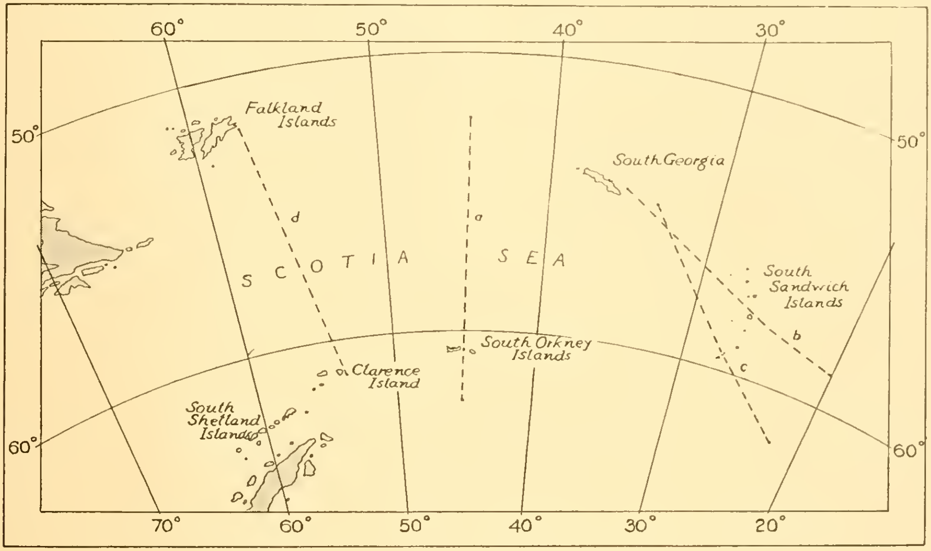


Fig. 11. Key chart showing positions of profiles in Fig. 12.

Another interesting feature of the soundings since 1932 is the discovery that the Burdwood Bank is separated from the main Falkland-Patagonian shelf by much deeper water than was formerly supposed. Eight additional lines of soundings were taken between the Burdwood Bank and the Falkland Islands and these have resulted in a marked change in the contours of this area (see p. 68).

It is now possible to construct four new profiles of the bottom in the area comprising the Scotia Sea and Arc (Text-fig. 11). Two of these cross the Scotia Sea from north to south and the remaining two run in east-south-easterly and south-easterly directions respectively from South Georgia. One of these (Text-fig. 12*a*), in approximately 45° W, extends for 620 miles and comprises 160 soundings. It crosses the well-defined ridge west of the Shag Rocks, illustrates the extensive folding on the northern side of the South Orkney Islands and shows the southward continuation of the South Orkney shelf to approximately 62° S. It should also be noted that the bottom just south of the Burdwood Bank-Shag Rocks ridge is likewise an area of considerable folding. The second cross-section (Text-fig. 12*d*), which is based on 107 soundings, runs from Cape Pembroke, Falkland Islands, to a position in line with, but slightly east of, Clarence Island, a distance of 575 miles. It shows some similar characteristics in that an area of considerable folding exists south of the Burdwood Bank—more

complicated indeed than in the area farther east—and in that the bottom rises steadily from the middle of the Scotia Sea towards Clarence Island; there does not, however, appear to be any evidence of folding just north of Clarence Island such as is a prominent feature of the bottom, for many miles east and west, a few miles north of the South Orkneys.

On the eastern side of the Arc the two new profiles of the sea bed begin east of South Georgia and north of the Clerke Rocks and, having crossed the Clerke Rocks-South Sandwich Islands section of the Arc in approximately the same position, continue in an east-south-easterly and a south-easterly direction. The profile shown in Text-fig. 12*b* commences in 54° 23·3′ S, 35° 30′ W, crosses the South Sandwich group slightly to the north of Saunders Island and continues across the South Sandwich Trench to 58° 50′ S, 20° 05′ W. There is a steady rise on the inside of the loop of the Arc to a well-defined ridge at the South Sandwich Islands, and beyond this the bottom shows a marked irregularity before dropping away abruptly into the Trench itself, across which a good line of soundings was obtained. The remaining section (Text-fig. 12*c*) begins slightly south and east of that just described, crosses the Arc in approximately 55° 15′ S, 33° W and, continuing through the South Sandwich Islands via the Douglas Strait, crosses the Trench in approximately 60° 30′ S, 25° 15′ W and finishes at 61° 55·2′ S, 20° 02′ W. The soundings between the South Sandwich Islands and the Trench unfortunately were few, owing to a breakdown of the transmitter, and although emergency repairs enabled us to get six extremely valuable soundings across the deepest part of the Trench, there was a further gap of some 60 miles in the line whilst repairs were again being effected. In the profile the bottom is shown as a dotted line for those periods during which the transmitter was out of action. A very good continuous record was obtained in the Douglas Strait on this occasion, though the maximum depth recorded—321 fm. (587 m.)—was nearly 100 fm. (183 m.) less than the greatest depth determined here during our survey of the South Sandwich group in 1930. Douglas Strait, which has been described by Kemp & Nelson (1931) in their account of our survey operations, lies between Southern Thule and Cook Island and is, geologically, an extremely interesting feature. It is a deep basin, with a maximum depth, so far determined, of 409 fm. (748 m.), and it is cut off at the entrance on either side by a ridge, on which there is an average depth of water of about 14 fm. (26 m.). There can be little doubt that Southern Thule and Cook Island originally were one large island and that this basin is the crater of an extinct volcano, an eruption of which probably separated the island into two. Our record in 1935 was taken on a line across the eastern side of the basin, and agreement with the contours previously determined was good.

In both the profiles just described it can be seen that the connexion between the Clerke Rocks and the South Sandwich Islands is not very clearly marked, although the deeper water of the western end of the South Sandwich Trench can clearly be seen at the beginning of each section. From this deeper water there is a well-marked rise to the line of the connexion, but of the connecting link itself there is little evidence here other than a rise of some 300–400 m. (164–219 fm.). This, however, when considered in relation to the extension of the Trench in a westerly direction, to a position north of the Clerke Rocks, may be held to constitute a connexion here; especially as there is considerable evidence of folding, such as is commonly found inside the loop on most of the other sectors of the Arc. The approach to the South Sandwich Islands from the west, both in the middle of the Group and at the southern end, is, however, an exception to the irregularity normally found inside the Arc. In each instance the bottom rises steadily towards the connecting ridge, as in the approach to Clarence Island (Text-fig. 12*d*), and it is probable that similar conditions prevail over the greater part of the northern side of the ridge between Southern Thule and the South Orkney Islands.

With the exception of those parts of the loop just mentioned it would appear that the slope of the bottom inside the connecting ridges of the Arc is, in general, steeper than outside. This is most

Fig. 12. Profiles of the bottom in the Scotia Sea and across the Arc. Vertical scale, ×25. Positions of soundings are marked on the horizontal scales. (*a*) North to south, between the latitudes of 52° and 62° 20′ S in, approximately, the meridian of 45° W. Based on 160 depths. (*b*) From 54° 23·3′ S, 35° 30′ W, across the South Sandwich Trench, to 58° 50′ S, 20° 05′ W. Based on 88 depths. (*c*) From, approximately, 55° 15′ S, 33° W, through the Douglas Strait and across the South Sandwich Trench, to 61° 55·2′ S, 22° 02′ W. Based on 131 depths. (*d*) Cape Pembroke, Falkland Islands to Clarence Island. Based on 107 depths.

noticeable in the region of the Burdwood Bank, around South Georgia, north-west of the South Orkneys and north-east of Elephant Island. The slopes off the South Orkneys are among the steepest we have met; they are certainly among the steepest slopes of any length from which we have been able to obtain a very good record, and we were fortunate to have fine weather in which to run the recorder when leaving Coronation Island, in a northerly direction, in February 1937. The record (see Pl. XXVI, fig. 1) covered 11 miles of the bottom, with a steady fall from the anchorage of 25 fm. (46 m.) to the edge of the shelf in 148 fm. (271 m.) and then an abrupt descent to a depth of 1514 fm. (2769 m.). The profile constructed from this record is shown in Text-fig. 13*a* with the vertical scale exaggerated 25 times and in Text-fig. 13*b* on the true scale. Soundings every minute were taken off the record to construct the latter, and the average gradient northward from the edge of the shelf, as determined graphically, is approximately 20°. The maximum slope here is approximately 25°.

Some shorter slopes of a similar magnitude have been observed on records taken in the channels of the Palmer Archipelago, during the surveys of the South Shetland Islands and in various channels leading seaward from Magellan Strait, but their length was generally only a fraction of a mile, and since the angle of approach to the contours was usually unknown, accurate analysis

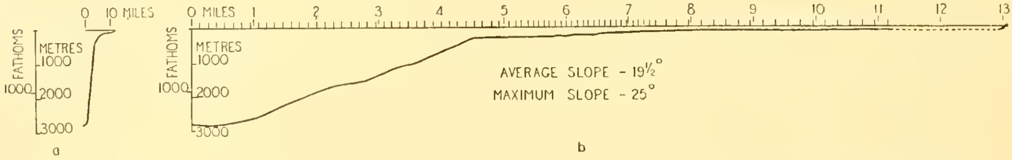


Fig. 13. Slope of bottom to the north, from Coronation Island, South Orkneys. Positions of soundings are marked on the horizontal scales. (*a*) Vertical scale, ×25. (*b*) True scale, based on 65 depths from continuous record.

has not been possible. In certain isolated instances, however, the density of soundings is such that a few contours can be drawn and the slopes which occur in these areas will be discussed in more detail in a later section of this report which deals with soundings taken during hydrographical surveys.

In these general remarks on the Scotia Arc it will be advisable, perhaps, at this point, to refer to some recent bathymetric charts which include this area. Stocks (1937), in one of a series of bathymetric charts of the Atlantic Ocean included in the 'Meteor' Reports, shows the contours of the eastern end of the Arc on a large scale. The western limit of this chart is the meridian of 30° W and the contours should, of course, be studied in conjunction with those of the area to the west; unfortunately, this chart, which covers the remainder of the Scotia Sea, was not published in Germany until 1941 and we have not, as yet, been able to obtain a copy.[1] The 'Meteor' soundings have, however, been published as lists of soundings (Maurer & Stocks, 1933) and we have used these in the compilation of our bathymetric chart. The depths obtained by the 'Meteor' which were shown on our original chart were only a small selection of soundings which had been supplied to the Hydrographic Department of the British Admiralty shortly after the return of the vessel.

In the eastern area which comprises the Arc, Stocks has based his contours mainly on one line of soundings obtained by the 'Meteor' in 1926 and on a selection of our soundings (presumably those which were published with our previous report or which have appeared in our Station Lists) together

[1] Since this was written we have obtained a copy of this chart. No contours are shown and most of the information was already known to us, but some hitherto unpublished soundings, taken by the whaling factory ship 'Walter Rau', provide valuable confirmation of our interpretation of the topography of the bottom in the neighbourhood of the South Orkney Islands.

with the further selection of our soundings which has been inserted on the relevant British Admiralty Charts. His interpretation of the outline of the northern and central portions of the South Sandwich Trench agrees therefore fairly closely with ours, although it lacks the confirmatory detail supplied by our more complete data. At the southern end, where all the soundings available are, with one exception, from the 'Discovery II', those used by Stocks, which are presumably those selected by the Admiralty from our lists and inserted in proportion to the scale of the relevant chart, are not quite sufficient in themselves to provide an adequate basis for bathymetric purposes. As we have shown in Pl. XXIII we consider that it is more probable that the 5000 m. contour, on the eastern side of the Trench, follows the line of the Trench to the south-west and that it does not join up with the small deep area of more than 6000 m. which lies approximately between the meridians of 22° and 23° W in latitude 61° S. In general the topography of the sea bed in this area appears to be extremely irregular and it is more likely that this secondary deep area, together with the area of more than 5000 m. in depth lying between 22° W and 25° W, in 62° S, are further evidence of the system of parallel folds which is so prevalent in other sectors of the Scotia Arc.

The Scotia Sea and South Sandwich Trench are also included in a bathymetric Map of Antarctica (1939) produced by the Department of the Interior, of the Commonwealth of Australia. As in Stocks's chart, this map is contoured in metres, and for the area in which we are concerned the contours in general follow closely those of our previous bathymetric chart, but a considerable number of amendments have been made to conform with our more recent work. This is most noticeable in the Burdwood Bank-Shag Rocks section of the connecting link, though the lack of a 500 m. contour here tends to give the impression that the Burdwood Bank is part of the continental shelf on which the Falkland Islands lie, rather than an integral part of the Arc, as is shown clearly on our present chart. The outline of the South Sandwich Trench agrees well with our latest interpretation of the soundings here, and certain of our shallow soundings between the South Sandwich Islands and the South Orkneys have been plotted. The wide shelf to the south and east of the latter group of islands is also well defined. The complicated form of the link between Coronation Island (South Orkneys) and Clarence Island is extremely well shown for the small scale used, as is also the trough which extends through the Bransfield Strait to a position south of Clarence Island.

The third recent bathymetric chart is U.S. Chart No. 2562 produced by the United States Hydrographic Office in 1943. This map, which comprises a wide area around the Antarctic Continent, is contoured in fathoms; it is not, therefore, so easily compared either with our own chart or with those of Stocks and the Commonwealth of Australia. There are, however, certain discrepancies in the Scotia Sea area (some of which are referred to in a brief review by Hinks & Mackintosh, 1943), and these should be mentioned here, since it would appear that some of the data available have been overlooked. Perhaps the most important discrepancy is in the representation of the South Sandwich Trench, where the deep water at the north-western extremity is shown as lying mainly south of latitude 55° S with a pronounced south-westerly trend, and where also the width at the southern end is given as some 60 miles between the 3500 fm. (6401 m.) contours. Between the 3000 fm. (5487 m.) contours in the same latitude the width of the Trench is shown as approximately 80 miles. Both these widths are far in excess of either our own or the Australian interpretation of the data then available. In the neighbourhood of the South Orkneys the Bart Bank (in approximately 61° S, 41° 20′ W) is shown as part of the ridge connecting these islands with the South Sandwich Group, but, if reference is made to British Admiralty Chart No. 3176, the soundings there shown give little indication that this bank is connected with the South Orkney shelf. In view of the previous evidence of multiple folding in the various sectors of the Arc it is, in our opinion, more probable that this is an isolated bank or part of a bank, which lies in an east and west direction and which is parallel to the main

ridge.[1] Farther to the west the complexity of the ridge connecting the South Orkneys with Clarence Island is not very clearly shown, and a ridge, the existence of which must be regarded as doubtful, is shown as running north-west for some 220 miles from Elephant Island; our soundings here do show a small area less than 2000 m. in depth some 75 miles from Elephant Island in the same direction, but there appears to be little evidence in support of the connexion of this area with the island. In the Bransfield Strait the outline of the comparatively deep basin is not well shown. In part this may be due to the small scale of the chart but it would also appear that the compilers have overlooked the data published in pl. xlvii of our previous report.

Certain banks shown on this chart are referred to as 'seamounts', a term which does not appear to have been among those considered by the International Committee of 1936 (see p. 60). It appears, however, in the terminology of submarine topography given by Sverdrup, Johnson & Fleming (1942, p. 25), where a 'seamount' is described as 'an isolated mountain-like structure rising from the ocean bottom'. In the present report the original term 'bank' has been retained for all such features.

DETAILED ANALYSIS OF THE SECTORS OF THE SCOTIA ARC

TIERRA DEL FUEGO TO THE SHAG ROCKS

In pl. xlv in our previous report the contours of the Arc were drawn to fit as well as possible the data then available. These contours need considerable modification in the light of subsequent soundings, and it therefore seems worth while to examine the various sectors of the Arc as before in some detail.

Very many more soundings have been taken in the vicinity of the Burdwood Bank, which is an accepted feature of the Arc, with the result that the area of the bank, of less than 250 m. (137 fm.) in depth, has been considerably reduced. Six lines of soundings were run across the bank between 1932 and 1938, one at the western end, two in the middle and three, in a southerly direction from Cape Pembroke, at the eastern end. A series of soundings, crossing the north-west corner of the bank, was also taken in 1936, in 54° S, as part of a line of soundings from South America to South Georgia. A further line, approximately south-east by south from Cape Pembroke, was of great value in the determination of the eastern limits. North of the bank these various lines have proved beyond doubt that there is relatively deep water between the bank and the Falkland-Patagonian shelf. A large area with depths greater than 500 m. (273 fm.) is found here and extends considerably west of the longitude of the Falklands. Depths of more than 1000 m. (547 fm.) extend along almost the whole northern side of the bank, the western limit of the contour being in, approximately, 60° 15′ W. The 2000 m. (1094 fm.) contour can now be shown to lie in about 58° 45′ W and a corresponding alteration in the 3000 m. (1641 fm.) contour can also be made in view of this fresh evidence.

The separation of the Burdwood Bank from the continental shelf would now appear to be firmly established and the profile running south from Cape Pembroke across the Scotia Sea, which we have

[1] The soundings taken by the 'Walter Rau' and already mentioned in the footnote to p. 66 indicate that there is some doubt about the existence of the Bart Bank, at any rate in the position at present assigned to it. The information available from Stocks's map shows that the 'Walter Rau' obtained at least three soundings exceeding 3000 m. (1641 fm.) at or near the position of the bank, and what is perhaps more important, obtained further deep soundings between here and the Orkney shelf. This latter evidence strongly supports our contention that if the Bart Bank does exist at or near the position now shown for it, then it must be an isolated feature.

There is little information about this bank. It first appeared on British Admiralty Chart No. 3176 in 1941 and the authority for its insertion was a Norwegian chart dated 1938 (private communication to the author from the Hydrographic Department of the Admiralty). The only other references to the bank which can be found appear to be on U.S. Chart No. 2562 (referred to above) and a very brief statement in the *U.S. Sailing Directions for Antarctica*, 1943 (p. 259) of the position and depths found. No authority is quoted in support of this information.

already shown (Text-fig. 12*d*), illustrates clearly the gradual descent of the continental slope from the Falkland Islands to a depth of slightly over 3000 m., the comparatively sharp rise to the bank itself and the fairly steep slope away to an irregular bottom at an average depth of 4500 m. (2461 fm.). South of the bank the contours as now drawn show that the slope is steeper than was supposed, though the average gradient as determined from five crossings is not more than $3\frac{3}{4}°$. Several good continuous records were obtained here with the 'Acadia' recorder and from these it can clearly be seen that one of the most prominent features is the considerable irregularity of the bottom down the slope. This is, perhaps, most clearly seen at depths of less than 3000 m. (1641 fm.). As we have already mentioned, such irregularity of the bottom, just south of the connecting link, appears to be a well-marked feature of this sector of the Arc.

Eastwards towards the Shag Rocks the recent soundings are in close agreement with those determined prior to 1932, and provide confirmation of the suggested line of the connexion. Nine more soundings of less than 1000 m. were obtained between 51° W and 53° W on the line from the Burdwood Bank towards South Georgia with a minimum depth of 581 m. (318 fm.). Farther to the east a series of soundings between South Georgia and the Falkland Islands provides valuable evidence of the extensions westward of depths of less than 2000 m. (1094 fm.), to a position in approximately 53° S, 46° 40′ W, and a formerly isolated sounding of less than 2000 m. is now linked up with the Shag Rocks, some 170 miles to the east.

The soundings obtained on this east and west line have been corroborated by five lines of soundings in a north and south direction, between the meridians of 43° W and 46° W. Agreement with the previous results was again very good. As will be seen from Pl. XXIII two of the lines in this series were run in weather which allowed soundings to be taken at intervals of 30 min. (except for one gap) or approximately every $4\frac{1}{2}$ miles, and there can be little possibility that any outstanding feature of the bottom was missed in this region.

Immediately south of the Arc, between 44° W and 45° W, and in the latitude of approximately 54° 30′ S, there is an interesting deep fold, some 50 miles in length as at present known, where two depths of more than 5000 m. were obtained. The western end was determined by the 'Meteor' in 1926 and was shown on our original chart as an isolated deep sounding. In November 1932 a line of soundings on a southerly course crossed this fold about 25 miles to the east of the position of the 'Meteor' sounding. No sounding of more than 5000 m. was obtained, but four depths, ranging between 4879 m. (2668 fm.) and 4998 m. (2733 fm.) were determined over a distance of 7 miles between the latitudes of 54° 30′ S and 54° 37′ S, in the longitude of 44° 36′ W. This narrow trench is followed by a sharp rise to a sounding of 2776 m. (1518 fm.) in a distance of $4\frac{1}{2}$ miles; equivalent, roughly, to a slope of 15°. This is considerably steeper than the slopes normally found far from land. It is based on only two soundings, and thus, although the angle cannot be less than 15°, the recorder might well show parts of it to be steeper, especially if the ship moved at right angles to the contours. This further proof of parallel folding adjacent to the main ridge must be regarded as strong support for the theory of the arcuate connexion.

In April 1934 the 'Discovery II' obtained a single sounding of 5088 m. (2782 fm.) at St. 1335 (54° 37·8′ S, 44° 12·6′ W) to the east of the previous line. Later, unfavourable weather prevented us from obtaining soundings on a line which crossed the fold from south to north, in approximately 45° 30′ W, at a point where the soundings of the 'Meteor' suggest an extension of the fold to the west.

In the immediate vicinity of the Shag Rocks the recent soundings show that the 500 m. (273 fm.) contour to the west of the Rocks should extend some 25 miles farther to the west; and the limit of the 1000 m. (547 fm.) contour in the same direction can now be determined with fair accuracy.

There still remains the gap in the Arc between the meridians of 48° W and 49° W. It is now seen that the width of this is considerably less than hitherto shown, though from the evidence of the soundings alone its existence must be considered as certain. Hydrological observations do not either confirm or deny its presence, although there is some slight evidence that a northward movement of cold bottom water may occur at this point. Soundings, however, show the gap to be connected with a narrow trough of moderately deep water which lies east and west, between the Arc proper and a parallel ridge to the north. This parallel ridge, which extends east from the Falkland Islands for some 600 miles, at depths less than 3000 m. (1641 fm.), and which has an area of 5000 sq. miles less than 2000 m. (1094 fm.) in depth at its eastern end, is an interesting feature. It extends east to the longitude of 41° 30′ W and there can be no doubt that from this position to some distance west of the Falkland Islands it is completely separated over its whole extent from the main line of the Arc. The trough which constitutes the separation is narrow, but for the greater part of its length is more than 3000 m. (1641 fm.) in depth. It can finally be traced, by the 500 m. (273 fm.) depth contour, to approximately 53° 30′ S, 63° 30′ W; about 150 miles west of the mean longitude of the Falkland Islands.

The soundings shown on our original bathymetric chart gave a strong indication that such a trough existed, although the extent of the northern ridge, as determined by the 3000 m. (1641 fm.) contour, was shown only to the longitude of 47° W. Our more recent soundings in this area, however, comprise two lines between the Falkland Islands and South Georgia, five lines in a north and south direction, and four on north-westerly and south-easterly courses. All these series of soundings cross this trough, and four of the north and south lines and three of the others crossed completely the eastern end of the Falkland Ridge. The area less than 2000 m. (1904 fm.) in depth, of which only the southern part is shown on our present bathymetric chart (Pl. XXIII), was thus fairly extensively sounded out and its limits determined with reasonable accuracy.

Geologically, this ridge parallel to the Scotia Arc raises some interesting questions. For example, the structure of the Falkland Islands bears not the least resemblance to any structure so far determined in the various sectors of the Arc, and yet there can be no doubt of the connexion between the Falkland Islands and the comparatively shallow area which lies some 500 miles farther east, thus forming a parallel fold, such as is symptomatic of the Arc in general. It is not, perhaps, within the scope of this report to discuss these implications, but it should be noted that soundings provide evidence of rather similar conditions north-east from South Georgia, fuller details of which will be given when we consider the soundings in that area.

SOUTH GEORGIA AND THE SHAG ROCKS

Soundings taken since 1932 immediately to the west of the Shag Rocks have already been mentioned, their effect on the contours here being quite marked; but new soundings north and south close to the Rocks, and eastwards to South Georgia, cause little alteration in our original conception of the contours in this area. Two lines of soundings, however, which crossed this part of the ridge in a north-easterly direction, enable us to complete the 2000 m. contour south of the ridge, which had been in doubt; but the new contour follows closely the original tentative line. South of the Shag Rocks the 3000 m. contour is found to lie some miles north of the line previously shown, thus reducing the width of the ridge to a considerable extent.

Our soundings clearly show that the Shag Rocks constitute an important link in the Scotia Arc; and it is of considerable interest to find geological evidence in support of this in Tyrrell's recent report (1945). Stones dredged from a depth of 199 m. (109 fm.) at St. 474 (1 mile west of the Shag Rocks) showed a preponderance of greenstones which, from a close examination, Tyrrell considers to be

'congruous with the whole assemblage of rock types found in the Scotia Arc'. They are, in fact, very similar to specimens from Tierra del Fuego and Clarence Island.

Recent work close around South Georgia itself has caused only minor alterations in our previous delineation of the contours of the shelf surrounding the island. On the other hand, offshore soundings beyond this shelf have been of some interest, especially in a north-easterly direction. Here we have found a considerable area, probably of not less than 2500 sq. miles, which is centred about 180 miles from land and where a number of soundings of less than 2000 m. (1094 fm.) have been obtained. The minimum depth determined here so far is 887 fm. (1622 m.), in approximately 53° 04′ S, 33° 27½′ W. Altogether, eleven soundings of less than 2000 m. were obtained from two lines across this bank, which for convenience of identification we shall refer to as the North-Eastern Bank.

Directly north of Cape Crewe is another but considerably smaller area of less than 2000 m. in depth, which was shown on our original chart. Recent soundings here do not materially alter the position of the contours, and the connexion of this bank with the shelf around the island remains almost as originally shown.

The American bathymetric chart previously mentioned is in near agreement with our conception of the connexion of this latter bank with South Georgia, but the North-Eastern Bank is shown as a major feature in a ridge termed the 'South Sandwich Swell', stretching away from South Georgia in a north-easterly direction for some 700 miles. We have not, as yet, been able closely to examine all our oceanic soundings in this area, but it does not appear likely that this ridge exists as shown in the American chart, and the North-Eastern Bank is certainly not connected to South Georgia at a depth less than 1500 fm. (2743 m.); our many soundings between this bank and the island show that depths of more than 3000 m. (1641 fm.) are found here over a wide area. It seems much more probable that the North-Eastern Bank is part of a ridge concentric with the loop of the Scotia Arc, a ridge which also includes the small area of depths less than 3000 m. (1641 fm.) immediately to the east of the bank, together with another recently discovered bank in a position centred approximately on 52° 45′ S, 24° 30′ W. This latter bank was only crossed once (October 1936) and the minimum sounding was 1012 fm. (1851 m.) in 54° 41′ 48″ S, 24° 09′ 54″ W. It is possible that this ridge is continued to the south and east, linking up with the depths of less than 4000 m. (2187 fm.) shown there in approximately the latitude of 55° S; and it may even connect with the shallower area far to the south again, in a position centred approximately on 60° S, 20° W. We have drawn the 4000 m. and 3000 m. contours to conform with this suggestion in so far as the banks to the north-east of South Georgia are concerned but, in the absence of intermediate soundings between the various banks, this interpretation must remain largely hypothetical.

If our theory is correct then, in view of the known structure of the Arc in general, and especially of the prevalence of folds parallel to the main line, it appears that the shallower depths farther again to the north-east (in approximately 50° S, 33° W, and from thence to approximately 47½° S, 37° W) will not be connected to the North-Eastern Bank but form a further small fold also concentric with the Arc proper. Much more work will be necessary before this point can be settled, but there remains no doubt that the main line of the Arc lies as we originally suggested, and not through a parallel ridge either north or south of South Georgia.

SOUTH GEORGIA TO THE SOUTH SANDWICH ISLANDS

The link between South Georgia and the Clerke Rocks was firmly established by our soundings prior to 1932, but the evidence in support of a connexion between the Rocks and the South Sandwich Group was not entirely satisfactory. Unfortunately our recent work does not provide much additional information. It can be seen in Pl. XXIII that although several new lines of soundings were taken in

this area, there is still a gap in the ridge between 30° and 31° 20′ W. However, there is still room in this gap for further soundings to reveal better evidence of a connecting ridge. Apart from this the following facts may be cited in general support of the connexion between South Georgia and the South Sandwich Islands.

(*a*) The profiles drawn in Text-figs. 12*b* and *c* show the typical irregularity of the bottom immediately south of the least depths (i.e. on the inner side of the loop), which is so marked in the Burdwood Bank-South Georgia sector of the Arc.

(*b*) The area of less than 3000 m. (1641 fm.) centred about 32° W, with its revised and more elongated outline (from west to east), may represent a crest on the ridge.

(*c*) A number of new soundings show that the northern end of the South Sandwich Trench extends westwards as far as 33° 37′ 48″ W (see Pl. XXIII). Since elsewhere the Trench is parallel to and outside the Arc, it may be supposed that part of the ridge lies just south of this westward extension of the 5000 m. (2734 fm.) contour.

Our original bathymetric chart showed the extension of the ridge on which the South Sandwich Group is situated as running roughly north from Zavodovski Island and then to the west. In late November 1932, soundings on a course approximately north-west from this island located a shallow bank some 35 miles away from land. The minimum depth determined was 174 fm. (318 m.) and altogether six soundings of less than 1000 m. (547 fm.) were obtained; four of these being less than 500 m. (273 fm.). Although this bank is close to the South Sandwich Group and therefore should, perhaps, be considered as part of the island ridge, we might also suggest that by its position and depth it is strong evidence of the trend of the connexion towards the Clerke Rocks and South Georgia.

SOUTH SANDWICH ISLANDS TO THE SOUTH ORKNEY ISLANDS

In Pl. XXIII several new lines of soundings can be seen on, or crossing, the ridge connecting the islands of the South Sandwich Group, and these give a much more accurate representation of the general outline of the ridge, certainly on the western side. Here it will be seen that the 3000 m. (1641 fm.) contour lies, in general, much closer to the islands than we had hitherto supposed and that the depths less than 2000 m. (1094 fm.) have been more precisely determined. In our previous chart the six southern islands (Saunders, Montagu, Bristol, and the Thule group—see Text-fig. 14) were shown as being connected by a ridge at a depth of less than 2000 m. (1094 fm.), but this has now been found to be incorrect. The saddle depth of the ridge between Montagu and Saunders Islands is now found to be greater than 2000 m., the least depth obtained being 1354 fm. (2476 m.), and although, so far as is known, no soundings have yet been taken between Montagu and Bristol Islands, similar conditions may well be found to exist here. The rise of the bottom to the saddle depth between Montagu and Saunders Islands, or between Saunders and Candlemas Islands is, however, almost 1000 m. (547 fm.), and is in itself sufficient evidence of the connecting ridge.

To the east of the South Sandwich Islands we have not gained so much information, except in the vicinity of Saunders Island, where the 3000 m. (1641 fm.) contour can now be placed with some accuracy. The two crossings farther south show a wider shelf at depths of less than 2000 m. (1094 fm.), with a consequent displacement of the deeper contours.

It will thus be seen that the connexion through the South Sandwich Group falls into three well-marked areas. At the northern end there is a comparatively shallow submarine plateau surrounding the islands, which stretches away in a north-westerly direction towards South Georgia. In the centre we have Saunders Island, Montagu Island and, probably, Bristol Island, rising from slightly greater depths. At this point also, the width of the ridge narrows considerably, the least distance between the 3000 m. contours being about mid-way between Candlemas and Saunders Islands. South of this the

ridge again widens and becomes more pronounced, the distance between the 3000 m. contours being approximately 100 miles, as compared with the width of 25 miles at the narrowest part.

We now come to the most important results of our recent sounding work in the area of the Scotia Sea and Arc; that is, the determination of some 200 miles of the connexion which we believe to exist between the South Sandwich Islands and the South Orkneys. Prior to November 1932, the largest scale British Admiralty chart for this area showed only three soundings of less than 2000 m. (1094 fm.). Early in that year, however, the 'Discovery II' had obtained a good line of soundings across the ridge in 36° W, with a least depth of 297 fm. (543 m.), and this was shown in our previous chart. For a large part of the year this region is covered by pack-ice, and it is unfortunate that in subsequent years the ship was not able to be there in the late summer when open water may be expected. The ridge is thus still inadequately explored, but one new line of soundings was obtained in November 1932, when the ice was farther south than usual for that month (see Mackintosh & Herdman, 1940, pl. lxix), and this can be seen in Pl. XXIII as an irregular line running from the South Orkney towards the South Sandwich Islands. The line is irregular because the ship was skirting the pack-ice throughout the passage. It would at any time be difficult to lay a course between the South Orkney and South Sandwich Islands which would include soundings on unknown parts of the ridge, but it happens that the course determined for us by the pack-ice resulted in some very informative soundings, especially between the meridians of 38° and 32° W. Here four well-marked areas of less than 1000 m. (547 fm.) in depth were found and in two of these the minimum depth was less than 500 m. (273 fm.).

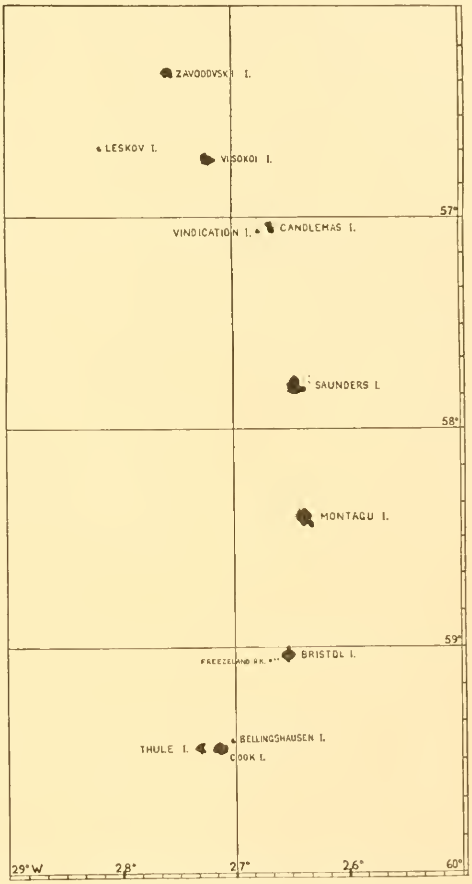


Fig. 14. The South Sandwich Islands.

This line first ran south from the South Orkneys to the ice-edge in the latitude of 61° 57′ S, and then turned to the east to follow the ice-edge. The soundings obtained on the southerly run, together with those at the beginning of the easterly course, show a remarkable extension of the South Orkney shelf to the south and east.[1] The first part of the eastward course must have lain south of any main connecting ridge, for it was not until the ship turned almost north in 37½° W that the first bank was located. Here six depths of less than 1000 m. (547 fm.) were determined and of these one was less than

[1] Soundings taken here by the 'Walter Rau' have already been mentioned in the footnote to p. 66 and they confirm this extension of the South Orkney shelf. Stocks's map, however, is on a comparatively small scale and it is probable that the soundings attributed to the 'Walter Rau' represent only a fraction of those taken. Nevertheless, of those plotted, there are 25 of less than 2000 m. (1094 fm.) and 20 of less than 1000 m. (547 fm.). They are in close agreement with our soundings and although it is not now possible to include them in our bathymetric chart (Pl. XXIII) their inclusion would have caused only local variations in the general trend of the contours shown for the South Orkney shelf.

500 m. (273 fm.); the minimum sounding was 373 m. (204 fm.) in 60° 53′ S, 37° 13′ W. Continuing to the north-east for a distance of about 35 miles the line of soundings then crossed the bank found on the northerly run earlier in the year. Agreement with the previous results was good and it was found that the hitherto isolated depth of 543 m. (297 fm.) could be linked up with a larger area. Four depths of less than 1000 m. (547 fm.) were determined on this north-east line and these included one of 488 m. (267 fm.), in 60° 17′ S, 35° 48′ W, roughly 9 miles east-by-north of the earlier sounding of less than 500 m.

From here the course still lay to the north-east, to the longitude of 35° 20′ W, where it became possible to turn east. Shortly after turning, and about 20 miles from the previous bank, another area with depths less than 1000 m. (547 fm.) was located. In all, seventeen soundings were obtained here and the minimum depth was 667 m. (365 fm.), in 62° 02·5′ S, 34° 41′ W. A number of these soundings were taken in a small area at the extreme eastern end of this bank, but it has not been possible to show all of them owing to the small scale of our bathymetric chart.

Not much farther to the east more shallow soundings were met with. Here ten depths of less than 1000 m. (547 fm.) were obtained over a distance of about 40 miles, the least being 602 m. (329 fm.), in 60° 00·5′ S, 32° 30′ W.

Between these last two shallow areas there exists a small gap, to which we have already referred in our general discussion on the Scotia Arc. Only one sounding of more than 3000 m. was obtained here (3807 m. (2082 fm.)), in 60° 03·5′ S, 33° 33′ W; the three remaining depths in the gap were approximately 1000 m. less.

The traverse of the ridge continued east from the 40-mile bank for about 30 miles. Unfortunately, the ice began to trend in a northerly direction here and we were thus prevented from obtaining soundings over the remaining distance of 110 miles to Southern Thule. The line now was directed in general to the north-east, towards Montagu Island, but the soundings obtained were of considerable value in the determination of the 3000 m. contour.

There still remains a wide area east of the South Orkney shelf where, so far as we are aware, no soundings have yet been obtained,[1] and there is also the gap to the west of Southern Thule. However, despite the lack of evidence from soundings in these areas, there can now be little doubt that the banks discovered in 1932 form part of a well-marked connexion between the South Sandwich Islands and the South Orkneys. Further evidence is provided by the indications of considerable folding at the western end of the portion of the ridge just described. Here, between the meridians 36° W and 38° W, is a complicated bottom of varying depths, such as is a common feature in other parts of the Arc. Steep slopes are prevalent and we have one instance, in approximately 61° 10′ S, 35° 03′ W, where a slope of 13° occurred between two soundings nearly 7 miles apart.

SOUTH ORKNEYS TO CLARENCE ISLAND AND THE SOUTH SHETLANDS

In our earlier report we stated that from the geological evidence then available the South Orkney Islands did not appear to form an integral part of the Scotia Arc, although soundings indicated that they were almost certainly a link in the chain. In January 1933 the 'Discovery II' made a running survey of the islands, and in the course of the work rock samples were collected from seven localities (Sts. 1089–1095) widely distributed among the group. These specimens were examined by Tilley (1935), who reported that in their general relationships they bear a striking similarity to rocks from the South Shetlands.

[1] Three soundings of less than 2000 m. (1094 fm.) were obtained by the 'Walter Rau' between 60° 15′ and 60° 25′ S, and in 39° to 39° 30′ W, which suggest that the 2000 m. (1094 fm.) contour on the northern side of the ridge should lie considerably north of the tentative line we have proposed in Pl. XXIII. The depths concerned are given as 1700, 1700 and 1800 m. (930, 930 and 985 fm.).

The connexion of the South Orkneys with Clarence Island was presumed before 1932, and we have now presented evidence from soundings which strongly supports the theory of a direct connexion between the South Orkneys and the South Sandwich Group. That the connexion is not likely to lie north of the former islands can be seen from Pl. XXIII; here we find more evidence of the folding which, inside the loop of the Arc, appears as a prominent feature of the bottom west of the meridian of 40° W. About 30 miles north and west of Laurie Island (the most westerly of the Orkney Group) is found the deepest area yet determined within the Arc; more than twenty soundings greater than 5000 m. (2734 fm.) have been obtained here by the 'Discovery II', the maximum depth being 5548 m. (3034 fm.) in 60° 16′ S, 43° 26′ W. It is also possible that this deep water extends farther to the west than is at present shown.

On the southern side of this trench the slopes are comparatively steep; one line of soundings in the longitude of 44° 30′ W gives an average slope of 16°, which is only 4° less than the very steep slope away to deep water immediately north of Coronation Island (the largest of the Orkney Islands) (see p. 66). To the north of the trench the bottom rises quite gradually to an extensive bank of depths less than 2000 m. (1094 fm.), which appears to be roughly circular in shape, with a diameter of about 45 miles. To the east this bank cannot extend beyond the limit now shown but it is possible that there may be a slight extension to the west. This, however, cannot be more than 20 miles as there is a well-sounded deeper area, of more than 4000 m. (2187 fm.), between the bank and the nearest depths of less than 2000 m. (1094 fm.) to the west.

The least depth obtained during our two crossings of this Orkney Bank was 1185 m. (648 fm.) in 59° 02·2′ S, 44° 33′ W. Altogether, nineteen soundings of less than 2000 m. were obtained.

These facts, together with the new geological evidence, provide almost certain proof that the South Orkney Islands are included in the main line of the Scotia Arc.

We suggested, in 1932, that the extension of the Arc westwards from the South Orkneys might be found to consist of two parallel submarine ridges, and this assumption now appears to be correct. From the evidence then available we also inferred that the main ridge lay between Coronation Island and Clarence Island. However, the many new soundings now available (especially east and south of the line of connexion) make it almost certain that it is the southern fold which represents the main line of the Arc, and that it connects the South Orkneys direct with the Trinity Peninsula of Graham Land. The northern ridge, which comprises the South Shetland Islands, Elephant Island and Clarence Island lies close to the main connexion, but at its eastern end fades out into deep water at the meridian of 48° W. In the light of our recent work it also appears more likely that the two areas of over 5000 m. (2734 fm.) in depth, which lie between the folds, are part of a continuous trough separating these folds; they are shown thus connected on our present chart. The scale of this chart is small and all our soundings in this area cannot be shown; we have, therefore, reproduced the South Orkney-Clarence Island sector of the Arc on a scale which permits the insertion of all our soundings. This is shown in Text-fig. 15, p. 76. The northern slope in the easternmost of the small 5000 m. trenches shown in this figure is, perhaps, the steepest we have met. In approximately 61° 12′ S, 48° W the depth altered abruptly from 1051 fm. (1922 m.) to 2874 fm. (5256 m.) in a distance of 3·8 miles. This is equivalent to an angle of slope of approximately 40°. The deepest sounding obtained here was 3111 fm. (5689 m.), about 8 miles to the north-west of the depth of 2874 fm.

Previously we described the South Orkney-Clarence Island sector as the last oceanic link in the chain of the Scotia Arc, but it now becomes evident that we must consider as a whole the soundings between the South Orkneys, the South Shetlands and Trinity Peninsula, together with the soundings north of the South Shetlands.

Fifty miles north of these islands we again have evidence of folding. Two soundings of more than

5000 m. (2734 fm.) were obtained here by the 'Discovery II' and it is probable that these are connected by a small trench. Forty-five miles approximately west-by-south of this is another small area where depths of more than 5000 m. were obtained by the 'Meteor' in 1926. The area between these soundings and those taken by us is completely unsounded and it is reasonable to suppose that further observations will show that a long but narrow trench extends over the whole distance. North of our 5000 m. soundings is a small bank, with depths of less than 2000 m. (1094 fm.). In fact, this area is very similar in structure to the area north of the South Orkney Islands, except that the slope from the deep water here appears to be slight but regular and the shelf to the north of the South Shetlands is fairly wide.

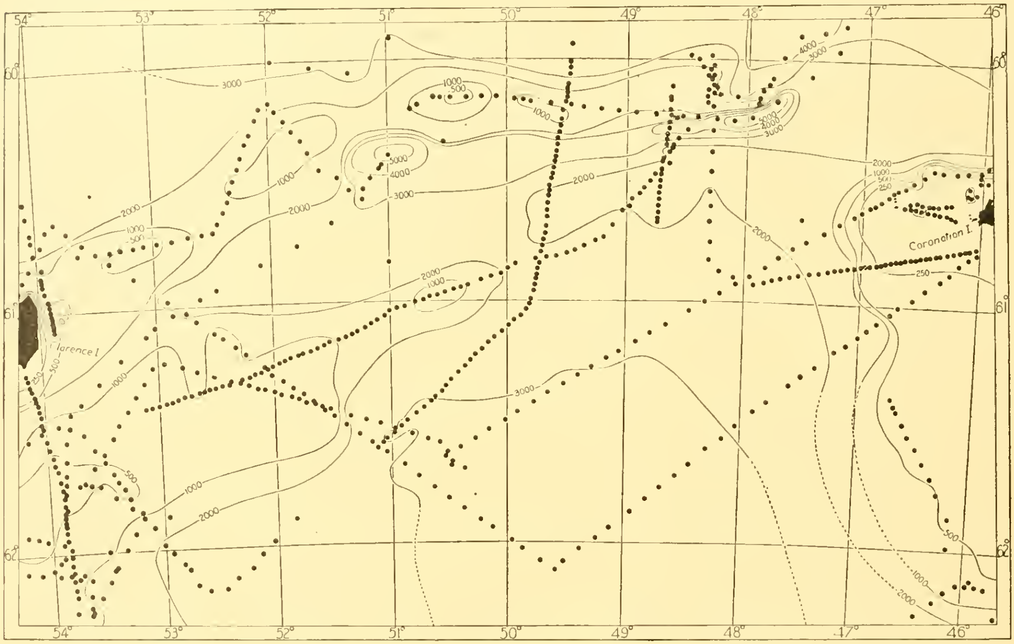


Fig. 15. The Scotia Arc. Positions of soundings and contours of the bottom for the section of the Arc between the South Orkneys and Clarence Island.

Between King George Island and Elephant Island information is scanty, but such evidence as is available no longer supports our original conception of a connexion here at depths of less than 250 m. (137 fm.); it now appears more likely that the average depth of water on the ridge is less than 500 m. (273 fm.), with a small bank of less than 250 m. in the centre. To the north of Elephant Island one line of soundings, however, showed that the rise from 1872 fm. (3423 m.) to 151 fm. (276 m.) was at an angle of approximately 13°.

If we now consider the contours of the Bransfield Strait in conjunction with those of the bottom west of Clarence Island it will be found that the deeper water of the strait can be traced, by means of the 1000 m. (547 fm.) contours, to a position to the north of Coronation Island, South Orkneys. Admittedly, the trough south of Clarence Island is very narrow, but there can be little doubt that it exists. The average depth of water on the ridge south of the trough is less than 1000 m. for a large part of its length; it seldom exceeds 2000 m. (1094 fm.) in depth and there is an extensive area south of Clarence Island where the soundings are less than 500 m. (273 fm.). The least depth determined by us on this

southern ridge was 305 m. (167 fm.) in 61° 36′ S, 53° 35′ W. In the Bransfield Strait many new soundings have made little difference in the general outlines of the bottom, but in our present bathymetric chart (Pl. XXIV) we have introduced a contour at 1500 m. (820 fm.) in order to show more clearly the deeper parts of the basin south of King George Island and south of Gibbs Island. It is now apparent that the width of the trough south of Bridgeman Island is much less than we had hitherto supposed, but there is no doubt of the continuity of the basin at depths between 1000 and 1500 m.

On the northern side of the Strait it will now be seen that the 250 m. (137 fm.) contour enters all the bays and straits on the southern side of the South Shetland Islands; in two instances, depths of more than 500 m. (273 fm.) occur just inside the entrance to a strait. Short slopes of considerable magnitude exist off this side of the islands, and details of some of these will be given when we consider the application of our soundings to the various surveys carried out by the 'Discovery II'.

Unfortunately we still lack evidence from soundings whether Bridgeman Island is connected with King George Island (see Herdman, 1932, p. 230). Such further soundings as have been obtained add but little to our previous knowledge, but in view of the opinion given by Tyrrell (1945), that from its geological structure Bridgeman Island may be considered to be an island of the South Shetland Group, we have now shown the 500 m. (273 fm.) contour as running south of this island.

SOUNDINGS DURING HYDROGRAPHICAL SURVEYS

The 'Discovery II' has been engaged mainly in oceanographical work, and little time could be allotted to hydrographic survey. Usually about a month in each commission was available for surveying in the Dependencies of the Falkland Islands, and it was often possible to spend a few days in such work elsewhere when opportunities arose. In the Dependencies it was decided that the method of 'running survey' would be most suitable having regard to the time available, the imperfection of existing charts, and the great extent of the coastline in the Dependencies. By this method a skilled navigator can obtain excellent results, and much ground can be covered in a short time.

The immense value of echo sounding during this type of work was clearly demonstrated during the running survey of the South Sandwich Islands by the 'Discovery II' in 1930. A full description of this survey has already been given by Kemp & Nelson (1931). In subsequent years the 'Discovery II' carried out a complete running survey of the South Orkney Islands and made very considerable progress with a survey of the South Shetland Islands by the same method—work which could not have been attempted without continuous echo soundings, on account of the numerous off-shore dangers common to nearly all islands in this part of the world.

At the time of the South Sandwich and the main South Orkneys surveys the 'Discovery II' was fitted only with 'listening' type echo-sounding equipment, with which the maintenance of a proper sounding routine entailed long hours of tiring work. Although some preliminary work had been done in 1929–30 the main South Shetlands Survey was not begun until December 1934, by which time the automatic recorder had been fitted to the deep-water set. Shallow soundings during this season still required the use of the 'listening' gear, but its use could be restricted to the minimum necessary for entering or leaving an anchorage or when shoal water was met with on passage round the islands. When the survey of the South Shetlands was continued in December 1936 both deep and shallow echo-sounding sets were fully automatic.

Since the fitting of the deep-water recorder other running surveys carried out by the 'Discovery II' include work on the three northernmost of the Balleny Islands (in 1936 and 1938), the examination of the neighbourhood of Tristan da Cunha and various passages through the lesser known channels of Magellan Strait. Many little known or imperfectly surveyed Antarctic and sub-Antarctic islands were

circumnavigated and depths approaching the Antarctic continent were determined, in March 1939, in the meridian of Greenwich, when it was also possible to make a rough survey of the ice barrier and coastline between this meridian and that of 4° E. Additions were also made to our previous work around South Georgia. The lines of soundings in the Ross Sea in 1936, and between 1936 and 1939 across the Discovery Bank (in approximately 42° S, 1° E) cannot, perhaps, be classed strictly as hydrographic surveys; reference to this work is made in a later section.

For the purpose of this report it is not necessary to describe the various surveys in their full detail. A short account of the work in each of the more important regions will, perhaps, suffice to give some idea of the value of echo sounding at these times.

SOUTH ORKNEYS SURVEY

A very complete account of the running survey of 1933 and of the preliminary work leading up to it has been given by Marr (1935). The 'Discovery' made a short visit to Signy Island in 1927, and in 1931 the 'Discovery II' made some observations on the west and north sides of Coronation Island. The principal survey was undertaken by the latter ship in a period of 28 days beginning on 2 January 1933, during which about 2250 soundings were made, mostly with the Pattern 751 'listening' type shallow-water set. Later on the 'Discovery II' made two further short visits in April 1934 and February 1937. On this last occasion (which was subsequent to the publication of Marr's report) the south coasts of the islands were free from ice and in the nine days available much was done towards the completion of the survey. Continuous soundings were taken with both recorders, and records representing some 41 hours of steaming (or, approximately, 240 miles) were obtained. The various tracks of the ship during this period of continuous sounding are shown in Text-fig. 3*c*, p. 46. Each record has a number, and reference to Appendix II of this report will provide fuller details.

For further details of the South Orkney surveys reference should be made to Marr. All that need be said here is that the shelf surrounding these islands (where the majority of soundings were taken with the shallow-water set) offers an interesting comparison with that of other islands comprising the Scotia Arc. At South Georgia, for instance, depths on the western side of the island are comparatively shallow over a fairly wide coastal shelf and the bottom is certainly more regular than on the eastern side. Here there are a number of fjords and glaciers, and depths of considerably more than 250 m. (137 fm.) are often found. The coastal shelf is narrower and much more irregular, with a greater mean depth.

Of the various islands comprising the South Sandwich Group only one, Leskov Island, rises sharply from moderate depths. At the remainder there is generally a narrow but shallow coastal shelf, although in certain places where there are signs of comparatively recent volcanic activity, moderately deep water is found close to land. The submarine crater in Douglas Strait, to which we have already made reference, is, perhaps, the most interesting example of these exceptions.

The coastal shelf around the South Orkneys is, perhaps, the most outstanding example of the varying features of these shelves in the whole Arc. The islands themselves are rugged in character and it might well be expected that considerable variations in depth would occur in the various straits and harbours, and off the coasts. With only a few exceptions such conditions are not found. In general the coastal shelf, straits and harbours are shallow, although two small deeper areas exist south-east of Signy Island and north of Larsen Island; the latter has a maximum depth, so far determined, of 348 fm. (636 m.) in a position approximately 1 mile north-east of Melsom Rocks (see British Admiralty Chart No. 1775—in Marr, 1935). On the northern side of the islands the coastal shelf, at depths of less than 250 m. (137 fm.), extends at the most for some 3 or 4 miles and the slopes away to deep water are considerable.

On the southern side of the South Orkneys, however, we find a coastal shelf considerably wider than is usual around the islands in the Arc. The shelf, as determined by the 250 m. (137 fm.) contour, extends for some 15 or 20 miles south of the islands, but it is the extension beyond here of depths between 250 m. (137 fm.) and 500 m. (273 fm.) which is, perhaps, one of the most interesting features in these parts. The 500 m. contour extends south to the latitude of 62° S and, as will be seen from our bathymetric chart (Pl. XXIII) of the Scotia Arc, a wide area is thus included. Furthermore, there is a very gentle slope from here to the 1000 m. (547 fm.) contour, and it is only then that a moderate slope to the greater depths occurs.

The extent of the coastal shelf in relation to the South Shetland Islands, to the survey of which we shall shortly refer, is again different to those already mentioned. To the north of the islands there is a comparatively wide shelf where depths do not exceed 250 m. (137 fm.), but over almost the whole length of the Bransfield Strait moderately deep water is found close to the south of nearly all the islands. In the southern part of the straits which separate the various islands, and in Admiralty and King George Bays, it will be seen (Pl. XXIV) that depths of more than 250 m. (137 fm.) extend in a northerly direction for some distance. In two instances the 500 m. (273 fm.) depth contour enters the Strait and the slopes here are among the steepest we have met. Nearly all the islands appear to be steep-to both on the southern side and in the various straits. Admiralty Bay resembles a fjord and moderately deep water extends almost to its head, but King George Bay is in general much more shallow. The shelf on the northern side of the group is generally flat, and the slopes away to deep water are gentle.

SOUTH SHETLANDS SURVEY

In 1927 the 'Discovery' carried out some preliminary work on the survey of the South Shetlands, but the number of soundings taken was small. Between December 1930 and March 1931 the 'Discovery II' was working in this area and considerable progress was made with a running survey of Livingston and Snow Islands. A total of 1432 soundings was taken around the western end of the South Shetlands and in the Bransfield Strait, to which reference has already been made in our earlier report (Herdman, 1932). In December 1934 and January 1935 further work by the same ship completed the survey of the islands, with the exception of the eastern half of King George Island. Continuous soundings were taken whenever possible with the 'Acadia' recorder, and the records obtained totalled 140 hours of steaming. The speed of the ship varied considerably with the ever-changing conditions of this survey, but it can safely be said that during this time we recorded soundings continuously over not less than 600 miles of the sea bed. In addition to these soundings the 'listening' type shallow-water set was used when entering or leaving a harbour or anchorage, and as a relief to the deep-water set when it became necessary to clean the hammer or make a small repair. Every effort was made to do this in depths at which the shallow machine could provide an alternative, but breakdowns did not always occur at perhaps the most convenient times. Some 1600 soundings were taken with the shallow-water set during the thirty-one days occupied on the survey.

The remaining work on King George Island was begun in December 1936 and, as before, continued for a month. The weather was bad throughout and it was not possible to finish the survey, although all that remained uncharted was a few miles of the north coast of the island. The part that remains unsurveyed, however, would be difficult of access by ship, even in the best weather. In fact, it may be said that a running survey along the northern coasts of the South Shetlands requires almost perfect weather, and even with this it would be extremely difficult. The shallow-water echo-sounding set was now fully automatic and continuous soundings were thus obtained from both shallow- and deep-water instruments. The records totalled 120 hours of steaming and represent, very approximately,

a survey of not less than 500 miles of the bottom. Owing to the thick weather prevalent this season not all these runs could be used for the survey charts, but although they were not accurate enough for a hydrographic survey certain sounding runs, made on dead reckoning, have been of considerable aid in the construction of our present bathymetric chart of this area. The ship's tracks during the periods of continuous soundings in 1934–5 and 1936–7 will be found in Text-fig. 4, p. 47.

With the exception of Nelson Strait, which is comparatively wide throughout its length, the straits between the islands of the South Shetlands Group are usually narrower at their northern ends. Moderately deep water is found in all the southern entrances, and throughout the straits, but the northern entrances are all shallow. In some instances they are unnavigable even by small ships. Rocks and reefs abound here, and there are strong currents.

In the straits themselves and around the southern coasts of the various islands there is little or no coastal shelf of shallow water, and the slopes up to the land are considerable. In McFarlane Strait, which lies between Livingston and Greenwich Islands, there are depths of more than 500 m. (273 fm.) in the southern entrance, and the 250 m. (137 fm.) contour extends for some 7 or 8 miles towards the northern entrance. Depths of more than 100 fm. (182 m.) were recorded for a further 3 miles in a northerly direction and only in one place, off Yankee Harbour in Greenwich Island, is there any resemblance to a coastal shelf. Here, a shallow shelf, with depths of less than 40 fm. (73 m.), stretches out for about a mile from the harbour entrance, but the slope away from this to the deeper water is considerable. The angle of descent averages from 15 to 18°, with a maximum slope of 26°. Yankee Harbour itself is of interest as, apparently, there is a bar at the entrance, with considerably deeper water in the anchorage.

The southern part of English Strait, which separates Greenwich Island from Roberts Island, is not more than $1\frac{1}{2}$ miles wide, but the width increases towards the centre of the strait before narrowing again for the northern entrance. A narrow trough, more than 250 m. (137 fm.) in depth, runs up the strait almost to the numerous small islands which infest the northern entrance. The coasts of both Greenwich and Roberts Islands fall away sharply into this trough for some miles, but with the widening of the strait into Discovery Bay the deeper water continues north close to Roberts Island. The average slope of the eastern side of this trough appears to be about 14°.

The topography of the bottom of Nelson Strait, which lies between Roberts and Nelson Islands, differs considerably from that of the others. The strait is wide throughout, with a minimum width of $6\frac{1}{2}$ miles, and the coastal shelf on the eastern side of Roberts Island extends for some 3 or 4 miles. The northern entrance, unlike those of the other straits, appears to be remarkably free from dangers, although there are strong currents and some tide-rips. Depths of more than 250 m. (137 fm.) are found on the eastern side of the strait, and this moderately deep trough then curves to the north-west towards the coast of Roberts Island. The western coast of Nelson Island is steep-to, and in a position a few miles south of Harmony Cove there is a small but moderately deep hole with a maximum depth, so far determined, of 324 fm. (593 m.). The slope into this hole from the south-east is approximately $23\frac{1}{2}°$.

With the approaches to Fildes Strait, between Nelson and King George Island, there is a marked change in the character of the bottom topography. South of Nelson Island there is a moderately wide coastal shelf and, although it is penetrated by depths of more than 250 m. (137 fm.) in the approaches to Fildes Strait and in Admiralty and King George Bays, this shelf continues along the whole south coast of King George Island. In the approaches to Fildes Strait, which in itself is only navigable by boats, and that with difficulty, depths of more than 250 m. (137 fm.) extend over a wide area, and are found moderately close to both shores. The slopes here are slight.

Admiralty Bay, in King George Island, reverts more to the character of the straits at the western

end of the South Shetlands and closely resembles a fjord. A trough with depths of more than 250 m. (137 fm.) extends almost to the head of the bay and although the 500 m. (273 fm.) contour along the south coast of the island lies several miles south of the entrance, soundings of more than 500 m. (273 fm.) have been obtained over a distance of 2 miles on a northerly course, just inside the entrance to the bay. The slope down from the coastal shelf at the western side of the entrance is considerable. On a course round Telefon Rocks into the centre of the trough the soundings increased from 35 to 220 fm. (64 to 402 m.) in 0·45 mile; this is equivalent to a slope of 25° and, since it is probable that our course was not at 90° to the line of the contours, the actual slope may well be a few degrees greater.

Farther to the east the 250 m. contour along the southern coast of King George Island swings north towards King George Bay and there appears to be a comparatively narrow trough of this depth extending about a mile into the bay. The slopes, however, are quite gentle and the greater part of the bay appears to be reasonably shallow. Continuing round the coast of King George Island to Cape Melville we find that the coastal shelf, with the exception of a few shallow indentations, remains fairly wide. To the east of King George Island we had assumed (Herdman, 1932) that a ridge with depths of less than 250 m. (137 fm.) existed between this island and Elephant Island (see p. 76). Our more recent work makes this assumption doubtful, and it is now considered more likely that the 250 m. contour swings north about 15 miles east of Cape Melville and then continues round the northern side of the island.

On the northern side of the South Shetlands there is a wide submarine shelf of less than 250 m. (137 fm.) in depth. It is generally quite flat, although the continuous sounding records occasionally show a sharp submarine peak suddenly rising some 150 to 200 ft. from it. One such peak, near Table Island, rose 198 ft. (Record XXX/34) from a level bottom of 57 fm. (104 m.) in less than a minute and normal soundings of more than 50 fm. (91 m.) were again being obtained within $1\frac{1}{4}$ min. As the speed of the ship was $3\frac{1}{2}$ knots this was equivalent to an upward slope of nearly 42°. These peaks, perhaps, are only to be expected, for, in sharp contrast to the southern side of the group, the northern coasts of the South Shetland Islands are infested with small islets and sunken rocks. As we have already stated, navigation is extremely difficult, even in fine weather, and for our running survey it was normally necessary to keep well offshore. The term 'foul', used in many places on the British Admiralty Chart of these regions (No. 3205), is an accurate description of these coasts.

The survey of 1936–7 finished with an examination of Gibbs, Aspland, Eadie and O'Brien Islands, though these are not strictly part of the South Shetland Group. These islands lie in a group about 20 miles south-by-west of Elephant Island, and our survey in February 1937 showed that Aspland, Eadie and O'Brien Islands lie together, in a north and south line, at the western side of the group. Gibbs Island, which is the largest in the group, lies in an east and west direction. Narrow Island, previously shown as a separate island near Gibbs Island, does not appear to exist. It is probable that it has been confused with a low conical hill connected to Gibbs Island by a sand spit some 2 miles in length which runs out in a south-easterly direction. Continuous soundings were taken around Gibbs Island, and close to Aspland Island, for a total of 18 hr. in two days, and these represent a survey of 52 miles of the sea bed (see Text-fig. 5*a*, p. 49). Considerable alterations were made to the previous conception of the outlines of the various islands comprising the group, and the soundings showed that all the islands were steep-to. The slopes, however, were moderate in comparison with those generally recorded in the South Shetlands.

BALLENY ISLANDS

In the Discovery Committee's programmes hydrographic survey has been concerned mainly with the Dependencies of the Falkland Islands, but when time and conditions permitted every opportunity was taken to examine little known or badly charted land in other regions. Among the most important of these miscellaneous running surveys was that of the three northernmost islands of the Balleny Group. These islands, the more northerly of which is situated in about 66° 35′ S, 162° 30′ E, were, up to 1936, very imperfectly known, and there was considerable doubt about their correct position. They have been sighted on several occasions since their discovery in 1839 but, with the conditions of pack-ice, fog and bad weather which normally obtain here, a close approach was not possible.

In February 1936, while returning from the Ross Sea, the 'Discovery II' found the Balleny Group clear of ice. A running survey was begun and an attempt made to land on Borradaile Island, but with the onset of thick weather it became necessary to abandon both the survey and the attempt to make a landing. There were no signs of improvement in the weather on the following day, and with fuel running low it was essential to continue on passage to Australia. Continuous soundings, however, had been obtained for 8 hr. during the clear weather, representing a distance run of 47 miles, and the tracks of the ship during this period are shown in Text-fig. 3*b*, p. 46.

During the second circumpolar cruise of the 'Discovery II', in 1937–8, a further attempt was made to complete the survey of the Balleny Islands. Approaching the group from the direction of Adélie Land, in January 1938, it was found that the northernmost islands were clear of ice, and as the weather was fine the running survey was resumed at the point where it had been abandoned in 1936. On this occasion the weather remained clear and it was possible to complete the circumnavigation of Young, Borradaile and Buckle Islands. Pack-ice to the southward prevented us from reaching Sturge Island, but the island was clearly visible at a distance of about 17 miles, and it was possible to fix its position approximately with relation to the remainder of the group. As our circumpolar cruise was, of necessity, being worked to a fairly rigid timetable, we were unable to remain at the Balleny Islands for more than two days. In that time, however, the ship covered a distance of 145 miles in 29 hr. of survey, and continuous soundings were taken throughout this period. As with the earlier work the tracks of the ship are shown in Text-fig. 3*b*, p. 46, together with an indication of the likely trend of the more important depth contours.

The Balleny Islands lie approximately in a line from north-west to south-east, and form the crest of a narrow ridge rising abruptly from the southern end of the Macquarie Rise, which connects the Antarctic Continent with Australia.[1] The general level of the bottom near the islands varies between 2500 and 3000 m. (1367 and 1641 fm.), and on the western side the slopes up to the group are considerable. One of our lines of soundings crossed the ridge about $3\frac{1}{2}$ miles north of Young Island, and the angle of slope from the west was $13\frac{1}{2}°$. So far as can be ascertained at present Young Island is steep-to on both sides, and the slopes up to the land from 2000 m. (1094 fm.) correspond in the west to that determined north of the island. To the east the slopes are much less, and from one of 11° at the northern end decrease steadily to 6° off Cape Douglas.

[1] On the U.S. Chart of Antarctica (see p. 67) a possible connexion between New Zealand and the Macquarie Rise is also shown, the link having been based, apparently, on one sounding of 1244 fm. (2275 m.). From a close examination of our lines of soundings in this area and a study of the hydrological data, it is not possible either to confirm or deny the existence of such a link, although the evidence from the soundings would tend to show that this sounding is more likely to be an isolated peak. Deacon (1937, p. 114), in his discussion of the distribution of the bottom water, considers that the hydrological conditions existing in the deep basin of the Tasman Sea may be due either to the basin being shut off by a ridge, or caused by the rugged nature of the bottom topography in this region. On the evidence now available it appears, therefore, that the existence of a connexion between New Zealand and the Macquarie Rise is doubtful.

Buckle Island appears to lie athwart the ridge. At the south-western corner of the island the slope to moderate depths is greater than off Young Island, 17° being the approximate angle, and corresponding to this we find that north of Cape Davis, on the eastern side, the slopes are approximately $12\frac{1}{2}°$. North and east of the island the descent to deeper water appears to be moderate.

No soundings were obtained on a direct line between Borradaile and Buckle Islands, but from the evidence of the line of soundings a few miles to the east it may be suggested that the ridge is continuous between these islands at depths of less than 500 m. (273 fm.). From the soundings obtained south-east of Buckle Island it appears probable that there is also a similar connexion with Sturge Island.

TRISTAN DA CUNHA GROUP

(Tristan da Cunha 37° 06′ S, 12° 18′ W)

In November 1933 the 'Discovery II' approached Tristan da Cunha from the north. Continuous soundings were taken with the 'Acadia' recorder from 36° 07′ S, 12° 31·5′ W to the anchorage, a distance of 57 miles. At the beginning of the run the bottom was comparatively level at depths varying between 2000 and 2100 fm. (3658 and 3840 m.), and this condition persisted to within a distance of approximately 12 miles from the island. From this point soundings shoaled continuously, though at times with considerable irregularity in the bottom, to a depth of approximately 1650 fm. (3017 m.). The slope now became much steeper, and from a depth of 1079 fm. (1973 m.) the 100 fm. (183 m.) line was reached in a distance of 2·9 miles; equivalent to an average slope of $18\frac{1}{2}°$. A maximum slope of 25° was recorded over a distance of 0·4 miles, between the depths, approximately of 350 and 165 fm. (658 and 302 m.). We have already referred to this slope (p. 54), which was one of the longest over which we were able to obtain continuous soundings, and the profile of the last 33 miles of the approach is shown in Text-fig. 9, p. 55.

On leaving the anchorage our course lay north-west, then west-by-south and, after reaching deep water, approximately south (see Text-fig. 3*a*, p. 46). Continuous soundings were again taken and the run continued to Nightingale Island and thence to Inaccessible Island, a total distance from Tristan da Cunha of 45 miles. West of Tristan da Cunha the 'Discovery II' passed just over 1 mile off-shore and the minimum sounding obtained was 130 fm. (238 m.). Shortly afterwards the depth increased rapidly from 171 fm. (313 m.) to 1044 fm. (1909 m.) and for the next 4 miles the bottom remained very irregular at depths varying between 956 and 1116 fm. (1748 and 2041 m.); there was then a gradual rise towards Nightingale Island, where there is moderately deep water close off-shore. Between Nightingale and Inaccessible Islands the bottom was again very irregular, with a maximum depth of 597 fm. (1092 m.) about mid-way between the two islands. The slope of the bottom in either direction from here was moderately steep.

At Inaccessible Island depths of 100 fm. (183 m.) were obtained at a distance of 2–2·5 miles from the land, both on the run across from Nightingale Island and on the line of departure to the south-west.

Tristan da Cunha, Nightingale and Inaccessible Islands are all steep-to, the two former to a greater degree. At Tristan da Cunha, on the approach from the north, depths of 100 fm. (183 m.) were reached at a distance of 1·7 miles from the land and on the departure to the north-west the edge of this narrow coastal shelf lay at a distance of 1·3 miles off-shore. To the west of the Island, as we have already stated, soundings were over 100 fm. at a distance of 1·15 miles from the land. Littlehales (1932, p. 21) has stated that submarine slopes of $33\frac{1}{2}°$ have been found at Tristan da Cunha; we did not record any slope of this magnitude but, in view of the evidence of our soundings about the nature of the bottom to the north and west of the island, such slopes may well exist.

MARION AND PRINCE EDWARD ISLANDS

(Marion Island, 46° 49′ S, 37° 49′ E;
Prince Edward Island, 46° 36′ S, 37° 57′ E)

In April 1935, the 'Discovery II' visited Marion and Prince Edward Islands, and during a partial examination of the group continuous soundings were taken over a period of 10 hr., representing a distance over the bottom of approximately 65 miles. The track of the ship during this work is shown in Text-fig. 3*d*, p. 46.

The islands appear to lie on a submarine plateau and are steep-to, with considerable slopes from seawards at certain points; the maximum depth recorded over the distance of 12 miles between the two islands was 142 fm. (260 m.). South of the south-west corner of Marion Island the sounding was 896 fm. (1639 m.) at a distance of 3·5 miles from land, which is equivalent, approximately, to a slope of 14°. From this position, on a course almost parallel to the south coast of the island, soundings shoaled steadily to a depth of 174 fm. (318 m.) in a position 3 miles south of the south-east corner of the island. This coastal shelf appears to extend for at least 3 miles east of Marion Island, but its full extent was not determined.

East of Prince Edward Island the bottom is irregular and there are some very steep slopes. At one point, parallel to the coast at East Cape, the depth increased from 19 to 197 fm. (35 to 360 m.) in 0·5 miles, which is equivalent to an average slope of 19½°; the major portion of this slope, however, was at an angle of 28°.

BOUVET ISLAND

(54° 26′ S, 3° 24′ E)

During a series of cruises from Cape Town in 1938–9 further soundings were obtained at Bouvet Island on two occasions. Altogether, continuous soundings totalled 10¾ hr. and covered about 80 miles of the sea bed. As we had already suspected from the soundings taken here in October 1930 during a running survey and the search for Thompson Island (Herdman, 1932), the bottom was found to be very confused and irregular at depths less than 1300 fm. (2377 m.). There is a sharp rise (in one instance at an angle of approximately 20°) to a narrow submarine shelf of about 2 miles in width, from which the island itself rises fairly steeply. A section of the continuous sounding record taken in 1938, when approaching the island from the north, is shown in Pl. XXIX, fig. 1, and provides ample proof of the varied bottom in this neighbourhood.

MAGELLAN STRAIT

Between November 1931 and November 1934, the 'Discovery II' made eight passages through Magellan Strait, but only on three occasions was the passage by way of the main channel throughout. The Cockburn Channel entrance to the western part of the main strait was used three times (October 1932, March and November 1934) and the entrance by Otway Bay and Sea Shell or Abra Channel once (December 1933). In October 1934 another route from the main strait to the Cockburn Channel was examined; this was by way of Pedro Sound, the Ackwalisnan Canal and Dynely Sound.

In December 1933 the 'Acadia' recorder unfortunately was out of action, but a full series of soundings was obtained at intervals of about 4 min. with the 'listening' sets, through Otway Bay and Sea Shell or Abra Channel. In March 1934 we were still without the recorder, but a good series of depths was determined over the whole length of the Cockburn Channel and into the main strait. In October of the same year the 'Acadia' recorder was again in use and we were able to obtain a continuous record over a period of 10¼ hr. during the passage from the main channel to sea via the Ackwalisnan Canal. On our return a month later the recorder was used for a total of 14 hr. and continuous soundings obtained from a position 55° 27′ S, 73° 40′ W to the main strait, via the Cockburn Channel.

All these channels are narrow and comparatively deep, with an extremely irregular bottom topography. At the northern end of Pedro Sound a maximum sounding of 232 fm. (424 m.) was obtained 4 cables off-shore, in a position where the width of the sound was only 1·15 miles. In the Cockburn Channel depths often exceeded 300 fm. (549 m.) and the maximum sounding of 377 fm. (691 m.) which was obtained here in October 1932 was in a position where the channel is barely 3 miles in width. The bottom here is extremely varied, and when the continuous record was taken, in November 1934, slopes of 10–15° were common; in one place the depth increased by 132 fm. (241 m.) in 3 min., which is equivalent, approximately, to a slope of 16°.

The entrance to the main strait by way of Otway Bay and Sea Shell or Abra Channel is very similar to those already described. The seaward entrance is shallow but once among the numerous islands through which the channel runs depths greater than 400 fm. (732 m.) were found over a considerable distance. The maximum sounding obtained by the 'Discovery II' in December 1933 was 478 fm. (784 m.), at a point where the channel is barely 2 miles in width. It is probable that the bottom here is also very varied but, as already stated, we were not able to obtain a continuous record on this passage.

SOUNDINGS OFF ANTARCTICA IN THE MERIDIAN OF GREENWICH

Between July 1938 and March 1939 a series of cruises was made by the 'Discovery II' to the south and west of Cape Town (see Text-fig. 18, p. 89). By these cruises throughout winter and summer, over the same area, it was hoped to obtain valuable information on the seasonal changes across the Southern Ocean, between South Africa and the ice-edge. On each cruise the ship steamed to the latitude of 40° S, on or near the Greenwich meridian and then southward as far as possible. She then worked across the ice-edge to the meridian of 20° E and returned to Cape Town approximately on this meridian. Routine soundings were taken on all cruises, since the course was never quite the same for each cruise, and the recorder was used whenever possible. In the first five cruises the 'Discovery II' was stopped by pack-ice far from the Antarctic Continent; but in the sixth cruise (January 1939) she reached a point some 19 miles north of the 'barrier', and on the seventh (in early March) she reached the barrier and sighted land.

On the sixth cruise a continuous record was begun in 68° 55·2′ S, 02° 05·3′ E at a depth of 2121 fm. (3859 m.), and for a distance of 42 miles southward there was a slight but steady upward slope, not exceeding 2°, which reached a minimum depth of 846 fm. (1547 m.) in approximately 69° 35′ S, 02° 05′ E, 3 miles north of the ice-edge. In this last 3 miles the bottom became more irregular, with some increases in depth, but had begun to shoal again shortly before the ice was reached in 69° 37·9′ S, 02° 07·8′ E. Here the depth was 1052 fm. (1924 m.), and from the soundings obtained 18 miles south of this position on the next cruise it would appear that this steady rise continues for some miles and that there is finally a much steeper slope up to the continent.

On the last of the repeated cruises (in March 1939) the barrier was first sighted in 69° 15′ S, 00° 12·1′ E and the sounding close alongside the northernmost ice-cape was 1114 fm. (2037 m.). Continuous soundings had been commenced some miles north of this point, in a depth of 1518 fm. (2776 m.), and records were obtained along the barrier to a position in 69° 05′ S, 04° 30′ E, a distance of 140 miles. The recorder was run for 28 hr. during two days and the track of the ship is shown in Text-fig. 16 (p. 86).

The depth shoaled fairly rapidly towards the barrier in this longitude, the slope of the bottom from seaward averaging 9½°, and this slope continued towards the land. In 69° 58·2′ S, 01° 31·0′ E the ship was probably about 5 miles from land and the sounding was 105 fm. (192 m.). As will be seen from the track in Text-fig. 16 the course then lay to the north-east and the depth increased rapidly. When the

'Discovery II' turned east, in approximately the longitude of 01° 45′ E the sounding was 648 fm. (1185 m.) and when she stood away from the ice during the hours of darkness the depth was 795 fm. (1450 m.) in 69° 47·8′ S, 02° 21·1′ E. Soundings remained variable on the return to the barrier on the following day, although there was a sharp rise in the bottom at one place of 328 fm. (600 m.) in approximately 3·5 miles. This rise occurred between the depths of 815 and 487 fm. (1491 and 891 m.).

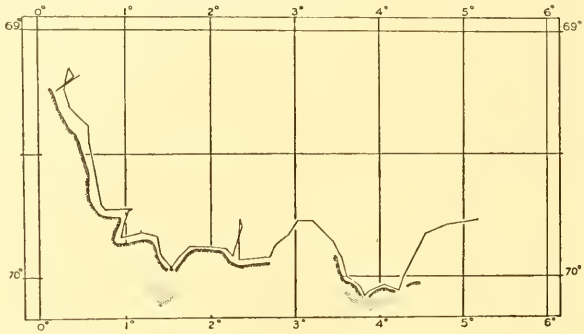


Fig. 16. Track of ship along ice barrier and coast of Antarctica, between the longitudes of 0° 10′ E and 4° 30′ E. Continuous recording of soundings throughout.

Shortly after the return to the barrier the ship was forced to the north by a field of bergs surrounded by heavy pack-ice, and soundings reached a maximum of 1010 fm. (1847 m.) in 69° 54·8′ S, 03° 32·1′ E. From this position the soundings again shoaled rapidly towards the land and after a steady slope a depth of 60 fm. (110 m.) was obtained 3 cables off-shore, in 70° 04·6′ S, 03° 49·2′ E. Land was again approached a few miles farther east and the least sounding obtained was 117 fm. (214 m.). Course was then altered to avoid pack-ice and to stand off the coast during the dark hours, but the weather deteriorated rapidly during the night and it was not possible to resume the survey.

THE CONTINENTAL SHELF OF ANTARCTICA

This short survey of 140 miles of the ice barrier revealed the interesting fact that over this distance there was virtually no continental shelf in the sense generally understood. Unfortunately, the pack-ice which surrounds the Antarctic Continent throughout the greater part of the year in most sectors makes the approach difficult, and it is only during late summer or autumn that ships can expect to close the land. It is not possible, without much more information than we now possess, to forecast, even remotely, the incidence of pack-ice, and thus any approach to the continent will remain for some years largely a matter of chance. Aerial reconnaissance, however, would be of considerable assistance in a clear ice year.

The information which has already been obtained from various approaches to the Antarctic Continent, and from running surveys of some short sections of the coast, leads us to believe that in some places the continental shelf is almost completely absent; one such area has just been described. Similar conditions are to be found in other parts of the Atlantic sector, and over considerable lengths of the coast between the meridians of 5° E and 60° E. There appears to be a wide shelf to seaward of the coasts of the Weddell Sea, and off the South Shetlands and South Graham Land there is a marked shelf, some 60–70 miles in width, which becomes wider as it continues south-west into the Bellingshausen Sea. No ship has ever reached the land between here and the eastern side of the Ross Sea,

but soundings obtained on the Pacific ice-edge suggest that a wide continental shelf exists in this sector. No land has been seen to the south from the various ships which took these soundings, and it may therefore be assumed that the shelf has a minimum width of 15 to 20 miles.

Off Marie Byrd Land and as far west as Cape Colbeck the bottom rises abruptly to a narrow shelf which widens out into the shelf which extends over the whole area of the Ross Sea (see Pl. XXV). At Cape Adare, at the north-western corner of the Ross Sea, the bottom again rises sharply from deep water to a narrow coastal shelf, and these conditions prevail to the west as far as the meridian of 158° E. Between this meridian and that of 130° E there is a wide area to seaward of the land where shallow soundings obtain, and in January 1938 off Adélie Land the 'Discovery II' took continuous soundings with the 'Acadia' recorder between 63° 53·1′ S, 135° 16·8′ E and 66° 13·8′ S, 139° 46·4′ E. The distance run was 170 miles, in approximately 19 hr., and the true course was south-east. Unfortunately, the weather during the last 12 hr. of this run was overcast and there were intermittent heavy snow squalls; these conditions, together with the unreliability of the magnetic compasses due to the close proximity of the South Magnetic Pole, made it impossible to assign positions for the soundings which would be acceptable for plotting on the charts. However, the accuracy of the positions, which were obtained by dead reckoning, is sufficient to prove the existence here of a wide continental shelf.

The run in to the land commenced at depths of approximately 2200 fm. (4023 m.) and the bottom remained fairly level at this average depth for about 40 miles. In approximately 64° S, 135° 30′ E the character of the bottom began to change and depths became very irregular. Soundings in general shoaled gradually to depths between 1200 and 1300 fm. (2195 and 2377 m.) during the next 60 miles of the run, and then remained approximately at this level for some 15 miles farther to the south-east. The bottom was still very irregular and there was no indication of a slope up towards land when, unfortunately, the magnetic coil in the head of the transmitter fused. A new coil was fitted and continuous soundings were resumed within an hour, but by this time the depth was 712 fm. (1302 m.) and it was obvious from the record that the slope up to the continental shelf had commenced. The edge of the shelf was reached in a distance of 3·65 miles from the resumption of soundings, at a depth of 247 fm. (452 m.). This represents a slope of just over 7° on a line of approach which was probably at an angle of 45° to the lines of the contours; the actual slope, measured at 90° to the contours, will almost certainly be greater.

After passing over the edge of the shelf which, at this point, lay in 65° 17·3′ S, 138° 19·5′ E (50 miles, approximately, north of Adélie Land), depths gradually increased to a maximum sounding of 335 fm. (613 m.) in 65° 39′ S, 139° 08′ E. From this position soundings shoaled fairly rapidly to a depth of 244 fm. (446 m.) in 65° 45′ S, 139° 22′ E and continued near this level until the deterioration of the weather forced us to abandon the approach in approximately 66° 14′ S, 139° 46′ E. The sounding in this position was 265 fm. (485 m.).

West of Adélie Land, as far as the meridian of 100° E, the line of the coast is in considerable doubt, but there is some slight indication of a fairly wide submarine shelf to seaward of the land. Between 100° E and 60° E the presence of a continental shelf is in general well established; its width is variable but gradually narrows towards the west. In 98° E it stretches out for at least 130 miles from the continent, but off Kemp Land, in approximately 60° E, the seaward limit of the shelf lies not more than 30 miles off the land.

Profiles, based on the continuous sounding records, have been drawn for the approach to the continent in the meridian of Greenwich and also for the run in to Adélie Land; they are shown in Text-fig. 17 (p. 88) and, in conformity with the profiles across the Scotia Sea and Arc, the vertical scale is magnified 25 times.

We do not propose, in this report, to discuss in detail this question of the continental shelf surrounding Antarctica. The presence of a well-defined shelf only in certain places may be found to be related closely to the existence, among others, of features such as the Kerguelen-Gaussberg Ridge

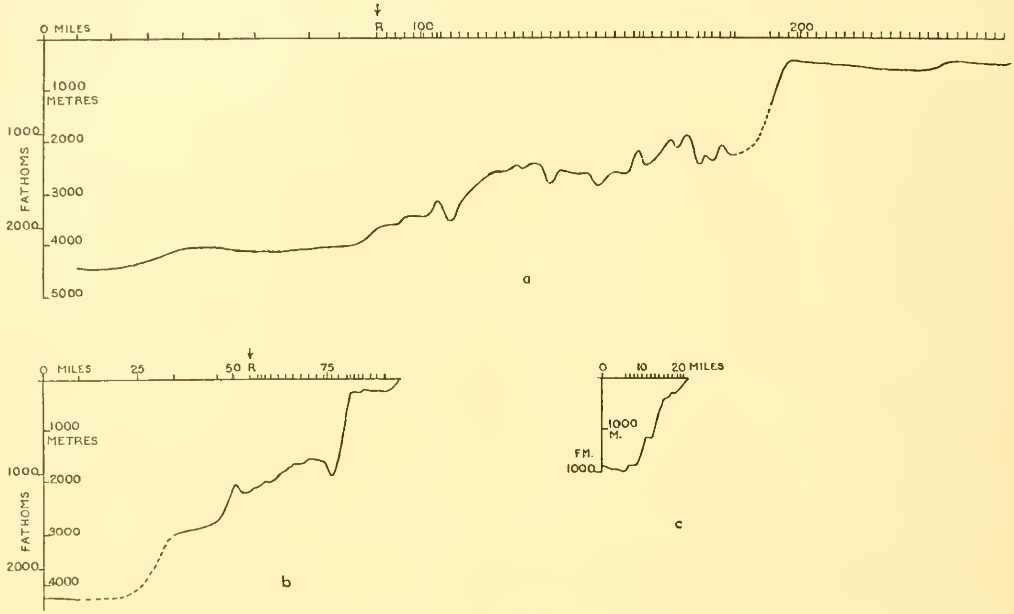


Fig. 17. Approaches to Antarctica. Vertical scale, ×25. Positions of soundings are marked on the horizontal scales. (*a*) Towards Adélie Land, on a south-easterly course. Continuous record from point marked *R*. Note wide continental shelf in this area. (*b*) In the meridian of Greenwich. Continuous record for 35 miles. Very narrow continental shelf. (*c*) In the longitude of 3° E. Bottom rises abruptly to the land from a depth of 1000 m. (547 fm.).

and the Scotia Arc. On the other hand, the width of the shelf may depend on the geological structure of the continent and the incidence of large glaciers. In order to arrive at any conclusion, however, about the relationship of the shelf with the various ridges which approach Antarctica from seaward, it will be necessary to examine the many thousands of oceanic soundings taken by the Discovery Investigations around the continent; it will, perhaps, be more suitable to revert to the continental shelf of Antarctica when we consider these soundings. It is hoped to begin this work in the near future.

SOUNDINGS IN OTHER LOCALITIES

The majority of soundings taken during the work of the Discovery Committee (and all of these outside the Atlantic sector) are from the 'Discovery II'. The principal tracks of this ship between 1932 and 1939 are shown in Text-fig. 18 (p. 89), and since soundings were taken at intervals of 8 or 9 miles throughout nearly all of these routes, it will easily be understood that they provide a very large number of new oceanic soundings south of 40° S. These soundings, added to the existing data, might justify the construction of a new bathymetric chart of the Southern Ocean. It is hoped to prepare such a chart later on, but in view of recently published charts and the prospects of additional data, it is thought better not to include it with the present report.

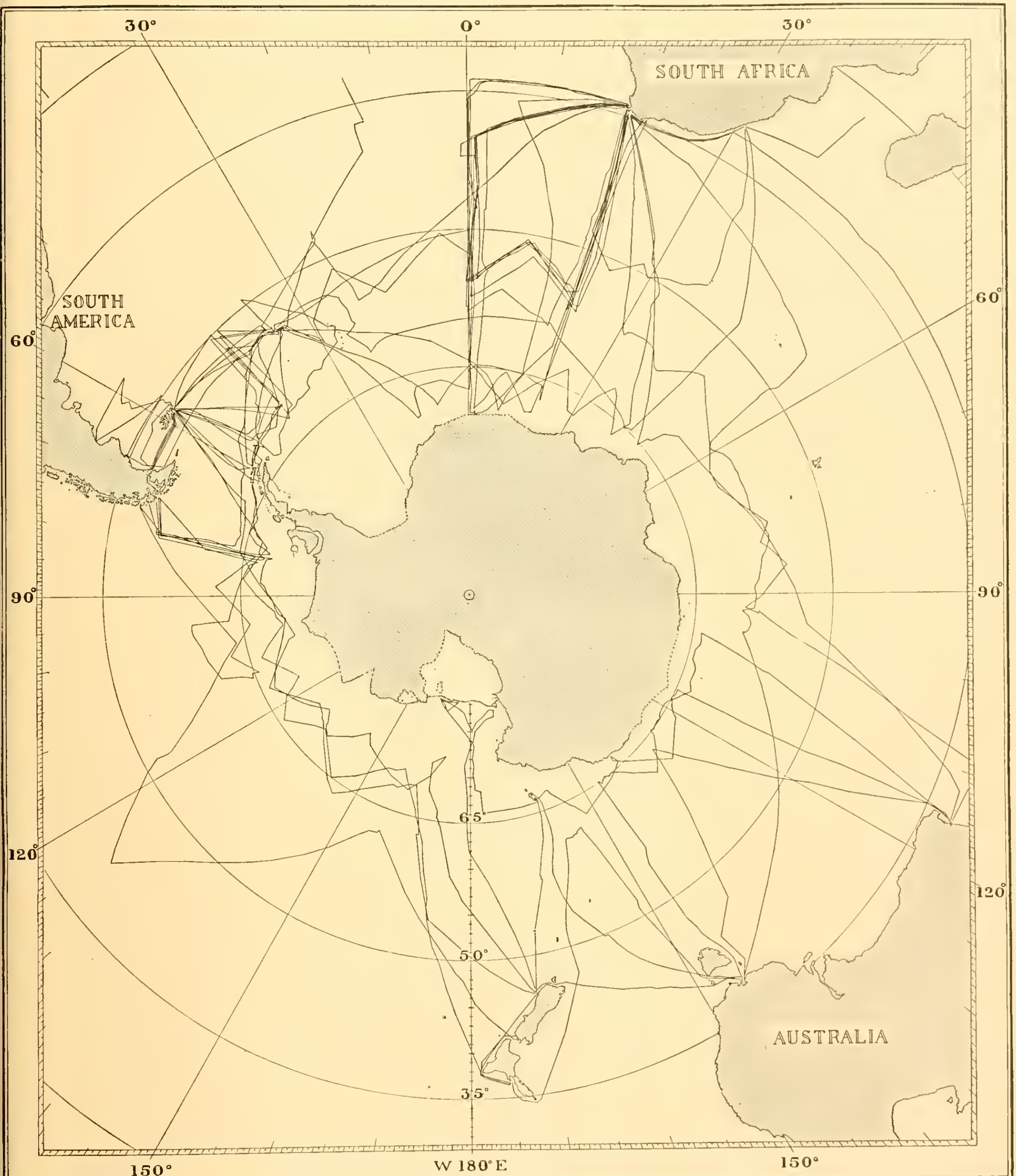


Fig. 18. Oceanic tracks of R.R.S. 'Discovery II' between May 1932 and March 1939. With the exception of a few unimportant gaps these tracks may be taken to represent lines of soundings.

Certain features in our general oceanic sounding work, however, deserve attention in this report, and among these are the recently discovered bank in the latitude of 42° S, close to the Greenwich meridian, and a series of soundings in the Ross Sea. We should also mention the soundings on the Kerguelen-Gaussberg Ridge.

DISCOVERY BANK

(Text-fig. 19)

The Discovery Bank was first located by the 'Discovery II' in May 1936. It was then crossed from north to south after a sounding of 560 fm. (1024 m.) had been reported in a position 41° 50′ S, 00° 01·7′ E. This comparatively shallow sounding followed a depth of 2287 fm. (4182 m.) obtained about 17 miles to the north. Soundings were then taken more frequently and a bank of less than 1000 m. (547 fm.) in depth was traced to the south for some 30 miles, the minimum depth obtained being 367 fm. (671 m.) in 42° 05′ S, 00° 06·2′ E. Later in the same year a good line of soundings was obtained with the recorder 14 miles east of the previous line. In the following year only one sounding, of 628 fm. (1148 m.), was obtained on the Bank.

The repeated cruises made by the 'Discovery II' to the south and west of Cape Town in 1938 and 1939 (see p. 85) presented further opportunities to obtain soundings on this bank. On the seven cruises which comprised this series the bank was crossed from north to south on five occasions and an attempt was made to run a line of soundings from west to east, to obtain evidence of the probable existence of two peaks, separated by moderately deep water. Unfortunately, bad weather prevented the completion of this line, but reference to Text-fig. 19 will show that a north to south line run subsequently leaves little doubt that two such peaks do exist. On the seventh cruise a line of soundings was attempted from north to south, in the longitude of 02° 30′ E, and, although soundings could not be obtained under way, conditions were such that any depths of less than 1000 fm. (1828 m.) should have been recorded.

The Discovery Bank lies in a stormy latitude and conditions are usually a severe hindrance to echo sounding. In consequence there are some unavoidable gaps in our lines of soundings but despite the adverse conditions agreement between the various lines was generally good.

Within a few weeks of our final run across the bank, the German ship 'Schwabenland', on her passage north from the ice barrier, obtained a series of soundings on the Discovery Bank, almost on the meridian of Greenwich. Through the courtesy of the Hydrographer of the Navy we have now obtained a list of these soundings, but unfortunately the positions given for the soundings in the critical area are noted by the ship as not being entirely reliable, on account of bad weather. When plotted, these soundings are not in agreement with our line of May 1936, which lies in approximately the same longitude, but from a close examination of all the available data it is probable that, on account of bad weather, our positions at this time are also not fully reliable, and that south of latitude 41° 30′ S our line should be plotted from 2 to 4 miles to the west of the position now shown. It seems likely that the positions given for the 'Schwabenland' soundings, between the latitudes of 43° S and 41° 30′ S, are some 3 to 4 miles north of their true position. Displacement to the west of our soundings and to the south for the German observations would bring these results into line with the remainder of our work on the bank but, with the exception of increasing slightly the north to south dimension of the area less than 500 m. (273 fm.) in depth, to conform to that determined by the 'Schwabenland', there would be little to be gained by moving our line, especially as we lack the necessary data from the ship's log-book to check further on the 'Schwabenland's' positions.

In Text-fig. 19, which has therefore been compiled from our soundings only, the actual depths are not given but the positions of the soundings are shown as dots. In most instances the contours, which

are in metres, have been determined directly from the 'Acadia' recorder, but it should be understood that, when continuous soundings are thus being taken, many more depths than those shown could have been plotted. For convenience in reading off the soundings from the record and determining the positions, soundings have been plotted at intervals of five minutes of time, over such distance as the record has been legible. It should, however, be remembered that with varying weather the speed of the ship was not necessarily the same for each crossing and, consequently, that the distance between soundings on different lines, being based on a fixed time interval, varies considerably.

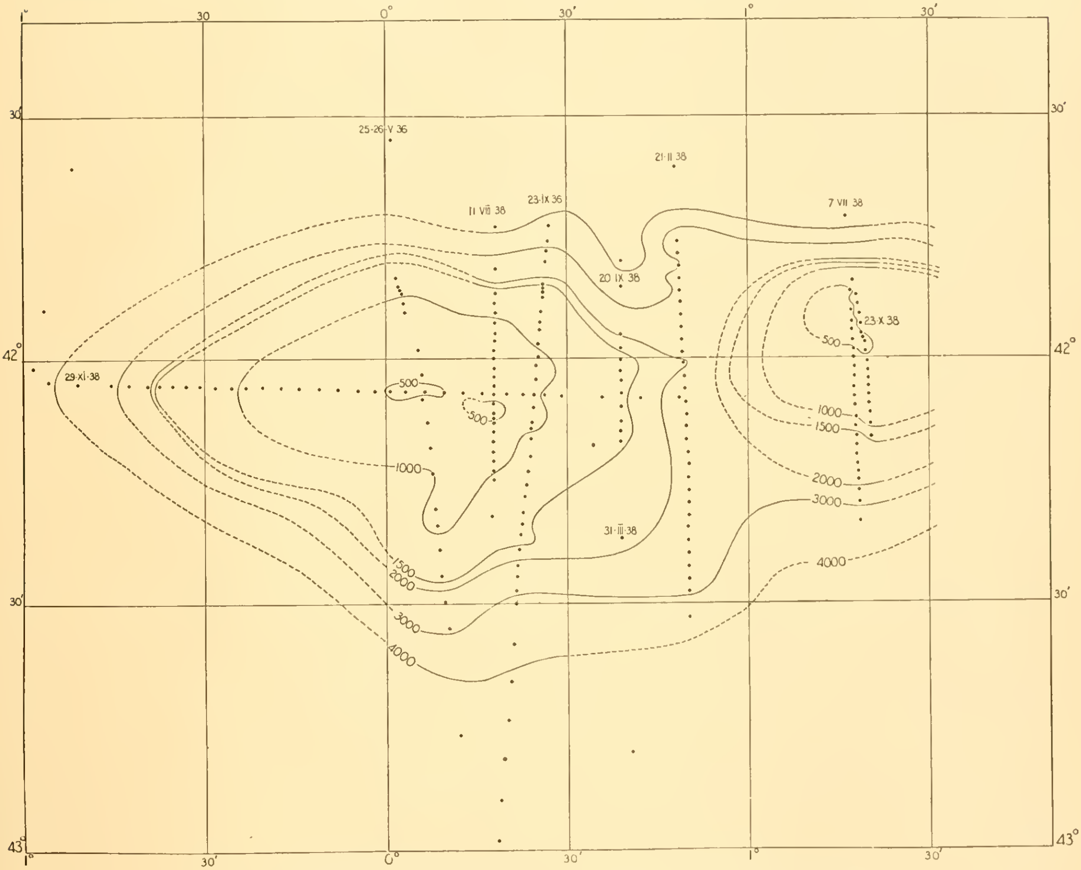


Fig. 19. Discovery Bank, contours in metres. Positions of soundings shown as dots.

The rise of the bottom on the northern side of the Discovery Bank is fairly steep, the average slope being approximately 10°. The maximum slope so far determined is approximately 12°. On the southern side the fall away to deep water is much less marked, the slope from the 1000 m. to beyond the 4000 m. contour averaging approximately $3\frac{1}{2}$°. The maximum slope barely exceeds 4°. The extent of the shallow water on the western half of the bank appears to have been determined with reasonable accuracy and depths of less than 1000 m. (547 fm.) cover an area of about 700 sq. miles. Two small areas with depths of less than 500 m. (273 fm.) and a minimum so far determined of 457 m. (250 fm.) have been

found on this side, and further soundings here may well show that these are part of a continuous ridge across the top of this part of the bank, although, as noted above, the 'Schwabenland's' observations suggest that this area of less than 500 m. (273 fm.) in depth may be more of a plateau than a ridge. We have not obtained sufficient information to determine the extent of the shallow water on the eastern half of the bank, though it seems probable that it extends some miles farther to the east. The least depth found here was 390 m. (213 fm.).

Two attempts were made to dredge on the Discovery Bank and the second, in November 1938, was successful. This was at St. 2493, in 42° 03·9' S, 00° 03·5' E, where three large rocks, a large number of smaller rock fragments and a mass of pebbles were obtained from a depth of 472 m. (258 fm.). Many of these pebbles were round and waterworn. All living organisms were smashed by the weight of rocks and pebbles but it was evident that a large species of sea-urchin and two or three species of Crinoid were common.

THE ROSS SEA

(Pl. XXV)

Soundings taken by Rear-Admiral Byrd's ship the 'Bear of Oakland' between the years 1933 and 1935 and by the 'Discovery II' in 1936 have provided much valuable information on the topography of the bottom of the Ross Sea. Prior to the work of these two ships our knowledge of the outlines of the sea bed here was scanty, and the few bathymetric charts available were based on a small number of scattered soundings, most of which were near the land on the western side, or were adjacent to the Ross Ice Barrier.

The most recent bathymetric chart of the Ross Sea, on a scale comparable to that of our present chart, is that of the American Geographical Society (1928). This map, of which sheets 3 and 4 cover the Ross Sea, includes a depth contour at 500 m. (273 fm.). Maps of a more recent date which include this area have been published, but they are on a much smaller scale, and the lack of a 500 m. contour in the Australian map of Antarctica (see p. 67) for instance, prevents the inclusion of most of the interesting features of the bottom topography of the Ross Sea. The U.S. Chart of Antarctica (see p. 67) also shows no depth contour above 500 fm. (914 m.), but more use appears to have been made of soundings taken by the 'Bear of Oakland'.[1]

Most of the soundings taken by the 'Bear of Oakland' were obtained during direct passages to and from the Bay of Whales and while cruising to the north and east of Cape Colbeck. The list of soundings also includes observations made during a cruise to meet the 'Discovery II' (in approximately 72° S, 171° W). Further soundings available from the same source were taken on the return of the 'Bear of Oakland' from New Zealand in 1935, when a cruise was made towards McMurdo Sound and thence south to Ross Island. From here the line of soundings ran across to the Bay of Whales, following closely the face of the Ross Barrier.

The soundings obtained by the 'Discovery II' in 1936 are shown in black in Pl. XXV and their location was determined largely by the necessity for quick passages, to and from the Bay of Whales, through the belt of pack-ice to the north of the Ross Sea. Some scientific work, however, was possible near the Bay of Whales and in the neighbourhood of Ross Island, and the soundings thus obtained have been of material aid in linking up our work with that of the 'Bear of Oakland'.

Our soundings are mostly in excellent agreement with those of the 'Bear of Oakland' where the two ships covered the same ground; but they also provide new information which, when added to the

[1] It is possible that the compilers of the Australian map did not have access to the full list of echo soundings taken by the 'Bear of Oakland'. These were published in manuscript form only, by the Woods Hole Oceanographic Institution, in October 1935. Reference in literature to this list does not appear to have been made other than by Roos (1937).

previous data, calls for some modifications of Roos's interpretation (1937) of the 'Bear of Oakland's' soundings. Roos refers to the 'Pennell Bank' as extending right across the Ross Sea from north-west to south-east; he also refers to the 'Iselin Bank', an isolated feature in approximately 72° S, 177° W. The conception of a shallow bank stretching across the Ross Sea from north-west to south-east appears to have originated with the American Geographical Society's bathymetric map of 1928, and the name 'Pennell Bank' for this feature was proposed by Griffith Taylor (1931). From the evidence now available it does not appear that this bank is continuous at depths less than 500 m. (273 fm.) across the whole width of the Ross Sea. There is probably a wide area in the north-western part of the Ross Sea where depths of less than 500 m. will be found, and it is highly probable that this is separated by a distance of about 60 miles from two moderately long but narrow areas of less than 500 m. in depth in the south-eastern part of the sea. Both ships obtained a few soundings of slightly less than 500 m. (273 fm.) in this gap, but reference to our present bathymetric chart (Pl. XXV) will show that there can be little doubt of the break in the continuity of the 500 m. contour. At the same time there can be no doubt that the general level of the bottom in the gap is above that of the south-western part of the Ross Sea.

At the eastern side of the larger bank to the north-west of the Ross Sea there is a narrow ridge, some 60 miles in length, where the soundings do not exceed 250 m. (137 fm.). Both the 'Discovery II' and the 'Bear of Oakland' ran along this ridge, the latter ship obtaining a minimum depth of 106 m. (58 fm.) in 74° 27′ 45″ S, 179° 58′ W. Since the existence of the original continuous bank across the Ross Sea now is doubtful, we propose that the name 'Pennell Bank' can be appropriately used for this limited area of less than 250 m. (137 fm.) in depth.

In our interpretation of the bottom relief in the region of the so-called 'Iselin Bank' we are of the opinion that this feature is not an isolated bank as suggested by Roos. It seems more probable that it is part of a considerable extension to the north, and finally to the north-east, of the wide shallow area in this part of the Ross Sea.

The main axis of this large and comparatively shallow region now appears to lie more in a south-west and north-east direction. To the west, between the bank and the Victoria Land Coast, there is a gully with an average depth of between 600 and 700 m. (328–383 fm.) and to the south-west depths of over 750 m. (410 fm.) are found north of Ross Island; these depths continue east for some miles along the face of the Barrier and it may well be that greater depths exist under the ice shelf itself.

It is, perhaps, on the eastern side of the Ross Sea that the greatest value attaches to the soundings of the 'Bear of Oakland'. Before the work done by this ship the information available in this area consisted of six soundings north of the latitude of 73° S and a few isolated depths of less than 300 fm. (549 m.) off-shore between Discovery Inlet and Biscoe Bay. Consequently, our knowledge of the topography of the bottom here was largely guesswork, but two excellent lines of soundings direct to the Bay of Whales, and the run up north to meet the 'Discovery II' in 72° S, have now provided sufficient evidence on which to draw a series of depth contours.

It is now evident that, at its seaward limit, the Ross Sea shelf runs approximately in a north and south direction between the latitudes of 72° S and 76° S. Over this distance the shelf is wide and the slope from seaward is only moderately steep. Southward from the latitude of 76° S the trend of the contours is almost in an east and west direction and the width of the shelf is reduced considerably; there is also a marked increase in the angle of slope between the 2000 m. and 500 m. contours. Further work by the 'Bear of Oakland' to the north-east of Cape Colbeck shows, as already noted by Roos, that the shelf is reduced in width to barely 15 miles, with an even sharper slope from seaward.

There still remains much work to be done in the Ross Sea before a more accurate conception of the bottom relief can be provided. Many more soundings are required between the latitudes of 73° and

76° S, west of the meridian of 179° E, and there is a serious gap to the east of the Pennell Bank. Here, between the 500 m. (273 fm.) and 3000 m. (1641 fm.) depth contours there is only one sounding in the distance of about 100 miles which separates the lines of soundings taken by the 'Discovery II' and the 'Bear of Oakland'. North of the Ross Barrier there is a large area, triangular in shape, where there are no soundings between the series obtained by the 'Discovery II' in 1936.

Few soundings have been obtained off the coasts of Victoria Land. Such as have been taken, however, suggest that this is a region of considerable interest, for in many places where the land slopes steeply down to the sea the bottom appears to descend rapidly to the 500 m. (273 fm.) contour or below. There is little or no shallow water for any distance from the coast, and just south of Terra Nova Bay (in approximately 73° S) a depth of 350 fm. (640 m.) is shown on British Admiralty Chart No. 3206 approximately $2\frac{1}{2}$ miles from the land. From the same source another sounding, near Cape Roberts (in approximately 77° S), shows a depth of 313 fm. (572 m.) only 3 miles off-shore. Off the Drygalski Ice-tongue existing soundings indicate the existence of a narrow trench, with a depth of slightly over 1000 m. (547 fm.).

Despite these gaps it is probable that the main features of the bottom relief of the Ross Sea are now tolerably well known; yet the results of our hydrological and biological observations made in the southern part of the sea are difficult to reconcile with our present interpretation of the bottom topography.

Deacon (1937, p. 115) in his remarks on the hydrological observations in this area supports the conception of a relatively shallow ridge, at depths less than 500 m. (273 fm.), between Cape Adare and King Edward VII Land, but he also suggests that there can be no channel through this ridge near the coast of Victoria Land. We have already shown that a continuous ridge at this depth across the Ross Sea almost certainly does not exist, but soundings in the gap indicate that the depth here is generally 100 to 150 m. (55–82 fm.) less than that of the area immediately to the south-west. This rise from the moderate depths of the southern part of the Ross Sea is probably sufficient to prevent the escape to sea of the cold bottom water, but on the present evidence from soundings it is difficult to agree with Deacon's suggestion that there is no deeper channel along the coast of Victoria Land. There can be little doubt now that such a channel can be traced as far north as the latitude of 73° S, and although there are only a few soundings north of this point it seems improbable that there can be any shallow connexion between Victoria Land and the 500 m. bank between here and Cape Adare.

KERGUELEN-GAUSSBERG RIDGE

The Kerguelen-Gaussberg ridge extends over a wide area, in a south-easterly direction from the island of Kerguelen to the Antarctic Continent. Rising on the average some 2500 m. (1367 fm.) above the general level of the ocean bottom on either side, the ridge separates the Atlantic-Antarctic and Australian-Antarctic basins. It exerts a profound influence on the hydrology of these regions of the Southern Ocean.

Between Kerguelen and Heard Island the ridge is comparatively steep-to on the western side and slopes away to deep water more gently in the east. South of latitude 55° S these conditions are reversed and it is on the eastern side of the ridge that the slopes become abrupt. From this latitude to that of 60° S the topography of the bottom is varied and there are two well-marked shallower areas. One of these is Banzare Rise, on the western side of the main ridge, which was discovered by the B.A.N.Z. Antarctic Research Expedition in 1929. The minimum depth determined by them, during two crossings of the rise, was 351 fm. (642 m.), in 58° 50′ S, 77° 44′ E. The U.S. Chart of Antarctica (No. 2562) and the Australian map of Antarctica both show a sounding of 103 fm. (188 m.) on the Banzare Rise; the source of this information, however, is not known to us.

On the extreme eastern side of the main ridge, south of latitude 55° S there appears to be a fairly well-defined narrow crest at depths less than 1000 fm. (1829 m.), and from the information now available it seems likely that this crest extends from a position a few miles south of Heard Island to the latitude of 58° S, following the line of the eastern side of the main ridge. At the extreme south-eastern end of the Kerguelen-Gaussberg ridge there is another well-marked shallow area, the Gribb bank (discovered by the whale-catcher 'Gribb' in 1937), which appears to rise sharply in approximately 62° S, 88° E; but owing to lack of soundings on the eastern side of the ridge, between this bank and the crest mentioned above, we cannot state whether Gribb bank is an isolated feature or whether it is part of a possible continuation of the crest south of latitude 58° S. It seems probable, however, that Gribb bank will be found to be connected with the crest and that it forms part of a shallower portion of the main ridge extending from Kerguelen to the latitude of 62° S.

The 'Discovery II' crossed the Kerguelen-Gaussberg ridge while skirting the pack-ice from west to east in April 1932, November 1935 and December 1937. Unfortunately the northern limit of the ice differed only slightly on each occasion and all three crossings were consequently made within a few miles of each other. In 1932 soundings were being obtained with the 'listening' type deep-water set, at intervals of distance varying with the weather, but which were between 2·5 and 4·5 miles; the minimum sounding was 956 fm. (1784 m.), in 56° 39·5′ S, 78° 37′ E. In 1935 continuous soundings over a distance of 75 miles were obtained with the 'Acadia' recorder, between 57° 27·5′ S, 74° 38·6′ E and 56° 55·2′ S, 76° 46·7′ E, and the minimum depth recorded was 1217 fm. (2226 m.) in 57° 04·7′ S, 76° 08·7′ E. Routine soundings at intervals of approximately 4 miles were then resumed, at a depth of 1397 fm. (2555 m.), but the depth again shoaled and a sounding of 1044 fm. (1909 m.) was obtained in 56° 32·8′ S, 78° 24·1′ E. The deep water of the Australian-Antarctic basin was reached in 56° 59·5′ S, 81° 23·6′ E, at a depth of 2548 fm. (4660 m.).

Continuous soundings for a distance of 275 miles were possible during the crossing of the Kerguelen-Gaussberg ridge in 1937 and a zigzag course was followed between 57° 26·6′ S, 74° 06·6′ E and 56° 56·5′ S, 80° 28·7′ E (see Text-fig. 2*c*). Depths generally were less than 3000 m. (1641 fm.) over the whole distance, and were under 2000 m. (1094 fm.) between 56° 53·2′ S, 78° 01·2′ E and 57° 18′ S, 80° 13·2′ E. The minimum sounding recorded was 910 fm. (1664 m.) in 57° 31′ S, 79° 38·8′ E. It will be of interest, perhaps, to mention here that at the point where the 1937 line crossed the 1932 line of soundings (in 56° 50′ S, 77° 54·5′ E) the sounding recorded in 1937 was 1164 fm. (2129 m.), which is only 15 fm. (28 m.) less than the sounding of 1179 fm. (2154 m.) obtained 1·2 miles north-east of this position in 1932. With the varied condition of the bottom prevailing here such agreement is gratifying.

The recorder charts for 1935 and 1937, especially the latter, showed by the multiple echoes recorded at many points that the bottom on the Kerguelen-Gaussberg ridge was extremely irregular at depths greater than 1100 fm. (2012 m.). At depths less than this conditions were the exact opposite; there was a completely regular bottom and no signs of any multiple echoes.

APPENDIX I

DEEP-WATER ECHO-SOUNDING SET

In 1933 an 'Acadia' type recorder was fitted to the deep-water echo-sounding set in the 'Discovery II'. This recorder, the scale of which was graduated in fathoms from 0–250, had an unlimited range, with phasing by 100 fathom steps: i.e. it was possible to 'step-back' or 'step-on' the transmissions so that the echo would always appear on the record. The principle of this recorder was quite simple: a transmission was sent out by the hammer normally at every complete revolution of the phasing switch,

i.e. every $2\frac{1}{2}$ sec. The returning echo was detected by a carbon-granule hydrophone, amplified, rectified and recorded on sensitized paper traversed by a stylus pen driven by the transmitter switch. The paper, which was supplied dry, had been sensitized during manufacture with a solution of starch and potassium iodide and, in the 'Acadia' pattern recorder, was wetted for use by passage over a wick which was fed from a tank behind the paper. When the stylus was traversing the paper and an echo or signal was received, the current at that moment passing through the stylus electrolysed the starch-potassium iodide solution in the wet paper and the iodine thus set free made a stain which commenced at the precise moment when the echo was received. As the paper travelled only at approximately 11 in. per hour past the stylus, the spacing of the returning echoes was so close that an almost continuous echo line was produced. In bad weather it was sometimes difficult to distinguish the echo mark from the other marks caused by extraneous noises in the hydrophone, especially in depths of more than 500 fm. (914 m.). Passage of the ship through brash ice, or pack-ice, had a similar effect (see Pl. XXX, fig. 1). It was possible to adjust the strength of the echo current by increasing or decreasing the sensitivity of the amplifier, but this had the disadvantage of having a similar effect on the strength of the water noises set up in the hydrophone. Therefore, in rough weather, it was often necessary to plug in the headphones to the telephone circuit and listen for the returning echo, marking it on the record, if necessary, with the electric pencil provided. Difficulty was also met when the returning echo coincided with an outgoing transmission, since the band, or mark, set up on the record by the transmission was of such intensity that an echo might be blanked out for a distance representing some 20 or 30 fm. on the record. A switch, however, was provided whereby it was possible to cut out any required number of transmissions without interference to the receiving circuit, and by careful manipulation of this switch it was possible to trace the line of the echoes through the transmission band. A typical example may be seen in Pl. XXXI, fig. 1. Without the use of the switch this transmission band would have completely obscured the echo at a depth of 1000 fm. (1829 m.). This cut-out switch was also used in determining the correct phase for soundings in waters of unknown depth. It will be appreciated that since the phase switch or dial was graduated only from 0 to 1000 fm., and that since a transmission was made automatically each time the phase switch arm passed zero, then an echo which appeared on the paper at a scale reading of, say, 200 fm., might equally represent 200, 1200, 2200, etc. fm. The correct phase, however, could easily be determined by cutting out all transmissions after the first, listening on the telephone circuit, and watching the number of times the phase switch arm had rotated before the echo was heard.

The recorder mechanism was driven by a governed electric motor, the speed of which required checking and adjustment as the set warmed up. A careful check with an accurate stopwatch was made therefore during long runs and the rate noted at intervals for the subsequent correction of the soundings. A note also was required, on the actual record, of any correction to the timing. If, for example, the motor ran fast by, say, 1% for 600 min. (which was quite a common period during survey work) the minute markings automatically recorded on the paper would at the end of the run be 6 min. ahead of the correct time and all the soundings recorded would be 1% too deep. This error in depth was negligible in soundings less than 100 fm. (183 m.) but, as we were usually approaching an unknown or imperfectly surveyed anchorage at the end of such a run, it was imperative for the subsequent plotting of the soundings that the correct time should be known for each depth plotted. Eventually it was found that nearly correct running ensued if the case containing the mechanism was left open; such minor corrections of speed as were then necessary could be applied by means of a sliding resistance which we fitted in addition in the ordinary governor circuit.

Throughout the whole period in which the recorder was in use, few repairs were needed apart from small mechanical and electrical adjustments. On one occasion there was a complete breakdown in

the amplifier due to a defective rectifier. Since spares were not readily available it was necessary to return the amplifier to the makers for repairs, and for some months only the 'listening' gear could be used. The only other serious trouble met with was the failure of the H.T. dry batteries to maintain a correct voltage. During survey work it was necessary to keep open the door to the echo cabinet and chart room, and the deterioration of the batteries is attributable to unavoidable exposure to much cold and damp weather. Some deterioration, however, also took place in new batteries stored on board. Eventually it was found best to replace the dry batteries with accumulators, and these were charged up every night during periods of surveying.

The old 'listening' type receiving gear needed little attention, but the transmitter (or hammer) gave considerable trouble, and eventually broke down in December 1934, during a survey of the South Shetland Islands. Temporary repairs were carried out by the ship's engineering staff, but the hammer was found to be worn out, and a new one was installed on the existing base plate some months later. This unit worked on the whole satisfactorily until 1939, and no replacements were required other than a new balanced head in 1938. The deep-sea hydrophone gave a certain amount of trouble in 1935 but a new unit was fitted at sea, through the sluice-valve provided, and from then until 1939 no further serious trouble was experienced. When the old unit was removed in 1935 it was found that the probable cause of the trouble was damage to the face by careless chipping of the adjacent hull plating in dry-dock. Precautions were then taken at other occasions of dry-docking to prevent a recurrence of such damage.

SHALLOW-WATER ECHO-SOUNDING SET

As stated on p. 43 a magnetostriction echo-sounding set, with a Mark XIID recorder, was fitted in the 'Discovery II'. The tanks containing the oscillators forming the transmitter and receiver were fitted to port and starboard of the centre line of the ship in No. 2 double-bottom freshwater tank. This position was 55 ft. from the fore perpendicular, and about 6 ft. forward of the position originally used for the Admiralty Pattern 751 sonic type receiver. The bridge instruments were fitted in the echo cabinet on the port side of the chart-house; the recorder, amplifier and contactor unit occupying no more space than that originally provided for the sonic receiving gear. H.T. and L.T. supply were arranged from the accumulators already in use for the deep-water set. No trouble was ever experienced with the transmitter or receiver, and when the author of this report had occasion to visit the ship during the course of his war-time duties with the Admiralty it was found that after $5\frac{1}{2}$ years immersion in a double-bottom water tank the transmitter and receiver were still functioning correctly. The recorder gave little mechanical or electrical trouble except for some difficulty with the change-speed gear box. Finally, to avoid their frequent renewal the train of gears for the high speed was removed and the machine solely used for sounding in fathoms. A serious defect, however, was the rapid fading of the records. In contrast to the 'Acadia' records which, after storage for as much as 14 years, have lost nothing of their clarity, the records from the Mark XIID recorder were liable to fade within a matter of hours, and it thus became essential to ink in the pertinent information as soon as possible. Some few records which were made in 1936, and stored unedited, are now quite illegible. The fading of the Mark XIID records (while the 'Acadia' records remain more or less permanent) is probably attributable to differences in the chemical impregnation and method of wetting in the two instances, the Mark XIID rolls being pre-wetted and supplied in sealed tins. Fading troubles experienced with early pre-wetted paper have since been largely overcome.

The maximum depths for which this set was designed were not achieved by us in practice and it is possible that the thickness of hull plating of the 'Discovery II' had a serious effect in diminishing the strength in both the transmission and reception of the soundwaves.

APPENDIX II

PARTICULARS OF RECORDER CHARTS, 1933–1939

Note. The abbreviation '(N.C.)' in the remarks column has been used whenever the run was interrupted for any appreciable time (such as for stations or when coming to anchor during a survey); after October 1935 it has also been used to denote those records where charts from both the Acadia and the M/S XIID recorders comprise the run. The time occupied by interruptions has not been included in the totals for the various runs.

Date	Record No.	Locality	Run in hours	Remarks
22–23. x. 33	I/33	47° 42·7′ N, 06° 18·8′ W to 45° 27·2′ N, 07° 55·5′ W	$12\frac{1}{2}$	Max. 2600 fm.
23–24. x. 33	II/33	45° 05·9′ N, 08° 45·2′ W to 42° 12·2′ N, 09° 56·5′ W	12	—
14. xi. 33	III/33	30° 57·5′ S, 13° 49·5′ W to 31° 17·2′ S, 13° 44·5′ W	2	—
15–16. xi. 33	IV/33	36° 07·9′ S, 12° 32′ W to anchorage at Tristan da Cunha	$5\frac{3}{4}$	Very steep slope
18. xi. 33	V/33	Tristan da Cunha to Nightingale and Inaccessible Islands	$7\frac{1}{4}$	Very steep slope
27. xi. 33	VI/33	53° 40·7′ S, 37° 07·3′ W to 54° 03·5′ S, 35° 25′ W	7	—
28. xi. 33	VII/33	54° 20·2′ S, 35° 25·2′ W to 54° 22·2′ S, 35° 53·4′ W	3	(N.C.)
		and approaches to Cumberland Bay, South Georgia		—
4. xii. 33	VIII/33	Sts. 1208–1209–1210	$4\frac{1}{4}$	(N.C.)
9. xii. 33	IX/33	62° 05·5′ S, 59° 21·2′ W to Bransfield Strait, via Nelson Strait	$3\frac{3}{4}$	—
9. xii. 33	X/33	Approaching Deception Island and through entrance, to anchorage	$1\frac{1}{4}$	—
28. xii. 33	XI/33	53° 43·2′ S, 58° 58′ W to 55° 10′ S, 59° 59·2′ W	10	—
29. i. 34	I/34	Approaching East Cape, North Island, New Zealand	$1\frac{1}{2}$	—
13. ii. 34	II/34	Cook Strait, New Zealand	$2\frac{1}{4}$	—
20. viii. 34	III/34	Simon's Bay to Cape Town	$4\frac{1}{4}$	—
9. ix. 34	IV/34	61° 55′ S, 60° 37′ W to (approx.) 62° S, 61° 30′ W	$3\frac{1}{4}$	—
16. ix. 34	V/34	53° 17·5′ S, 75° 45·5′ W to 52° 50′ S, 75° 04′ W	$3\frac{3}{4}$	(N.C.)
25–26. ix. 34	VI/34	54° 47·3′ S, 56° 37′ W to 55° 22·9′ S, 56° 04·1′ W	$4\frac{3}{4}$	(N.C.)
6. x. 34	VII/34	Entrance to Cumberland Bay, South Georgia	1	—
9. x. 34	VIII/34	South Georgia, Grytviken to Leith Harbour	$1\frac{1}{2}$	—
10. x. 34	IX/34	53° 40·6′ S, 38° 32·5′ W to 53° 26′ S, 40° 21·8′ W	8	Multiple trace
13–14. x. 34	X/34	51° 55′ S, 54° 45′ W to 51° 42·8′ S, 57° 32·5′ W	10	—
24–25. x. 34	XI/34	Magellan Strait to sea, via Pasa O'Ryan, Ackwalisnan Canal and Cockburn Channel	$10\frac{1}{4}$	(N.C.)
19–20. x. 34	XII/34 } XIII/34 }	55° 27′ S, 73° 40′ W to Magellan Strait, via Cockburn Channel	16	(N.C.)
6. xii. 34	XIV/34	61° 51·3′ S, 61° 50′ W to 63° 07′ S, 62° 55′ W	$8\frac{3}{4}$	(N.C.)
6–7. xii. 34	XV/34	Schollaert Channel, entrance to Neumayr Channel and return to Melchior Harbour, Palmer Archipelago	$4\frac{1}{4}$	Very irregular bottom
7. xii. 34	XVI/34	Melchior Harbour to (approx.) 63° 50′ S, 62° 30′ W	4	—
8. xii. 34	XVII/34	McFarlane Strait, from entrance to Yankee Harbour	$3\frac{1}{2}$	South Shetlands survey
11. xii. 34	XVIII/34	Survey of McFarlane Strait	$6\frac{1}{4}$	South Shetlands survey
12. xii. 34	XIX/34	McFarlane Strait to English Strait, via Bransfield Strait	$7\frac{3}{4}$	South Shetlands survey
13. xii. 34	XX/34	English Strait to Yankee Harbour, via Bransfield Strait	$7\frac{1}{2}$	South Shetlands survey
14. xii. 34	XXI/34	Yankee Harbour to Harmony Cove (Nelson Strait), via Bransfield Strait	$5\frac{3}{4}$	South Shetlands survey
15–16. xii. 34	XXII/34	Harmony Cove to Admiralty Bay	$5\frac{1}{2}$	South Shetlands survey
17–18. xii. 34	XXIII/34	Admiralty Bay to Harmony Cove	$6\frac{1}{2}$	South Shetlands survey (N.C.)
19. xii. 34	XXIV/34	Fildes Strait	$1\frac{3}{4}$	South Shetlands survey
19–20. xii. 34	XXV/34	Fildes Strait to Admiralty Bay	$3\frac{1}{4}$	South Shetlands survey
21. xii. 34	XXVI/34	Admiralty Bay to Fildes Strait	$4\frac{3}{4}$	South Shetlands survey

APPENDIX II (*cont.*)

Date	Record No.	Locality	Run in hours	Remarks
22–23. xii. 34	XXVII/34	Fildes Strait to Deception Island	12	South Shetlands survey
26. xii. 34	XXVIII/34	Deception Island to Yankee Harbour, via Livingston Island	$10\frac{1}{2}$	South Shetlands survey
27. xii. 34	XXIX/34	Yankee Harbour and McFarlane Strait	$1\frac{1}{4}$	South Shetlands survey
30. xii. 34	XXX/34	McFarlane Strait to Table Island, via north side Greenwich Island	$6\frac{1}{4}$	South Shetlands survey (N.C.)
31. xii. 34	XXXI/34	English Strait	$\frac{1}{2}$	South Shetlands survey
1. i. 35	I/35	Coppermine Cove to Harmony Cove, via Bransfield Strait	8	South Shetlands survey
2. i. 35	II/35	Harmony Cove to north side, King George Island	$3\frac{1}{2}$	South Shetlands survey
3. i. 35	III/35	North side, King George Island	$5\frac{3}{4}$	South Shetlands survey (N.C.)
4. i. 35	IV/35	North side, King George Island to Harmony Cove	$3\frac{1}{4}$	South Shetlands survey
5. i. 35	V/35	Harmony Cove to north side, Greenwich Island	8	South Shetlands survey
6. i. 35	VI/35	North side, Greenwich Island	1	South Shetlands survey
6. i. 35	VII/35	North end, McFarlane Strait to Desolation Island	$1\frac{1}{2}$	South Shetlands survey
7. i. 35	VIII/35	From Desolation Island along north side, Livingston Island	$6\frac{1}{2}$	South Shetlands survey
8. i. 35	IX/35	North side, Livingston Island to Desolation Island	$3\frac{1}{4}$	South Shetlands survey
9. i. 35	X/35	Desolation Island to Deception Island, via north side Livingston Island	$10\frac{1}{2}$	South Shetlands survey
11. i. 35	XI/35	De Gerlache Strait	$\frac{3}{4}$	—
19. i. 35	XII/35	Port Lockroy—Peltier Channel—De Gerlache Strait	$7\frac{1}{4}$	—
20. i. 35	XIII/35	Approaching Cape Roquemarel, Trinity Peninsula	$1\frac{1}{2}$	—
20. i. 35	XIV/35	Cape Roquemarel to Astrolabe Island	$3\frac{3}{4}$	—
20. i. 35	XV/35	Leaving Astrolabe Island	$1\frac{1}{4}$	—
21. i. 35	XVI/35	Passing Bridgeman Island	$\frac{3}{4}$	—
10. ii. 35	XVII/35	Douglas Strait, South Sandwich Islands	$1\frac{1}{4}$	Submarine crater
7. iv. 35	XVIII/35	Marion and Prince Edward Islands	10	—
23. iv. 35	XIX/35	22° 31·2′ S, 40° 25·7′ E to 22° 17·6′ S, 40° 28·8′ E	$1\frac{3}{4}$	Near Europa Island
23–24. iv. 35	XX/35	18° 12′ S, 41° 41·1′ E to 17° 52′ S, 41° 44·2′ E	2	Mozambique Channel (N.C.)
5. v. 35	XXI/35	Off Cape Gardafui	3	
7–8. v. 35	XXII/35	12° 54′ N, 43° 17′ E to 13° 37′ N, 42° 59′ E	4	Red Sea
8. v. 35	XXIII/35	Zubair Islands	1	Red Sea
8. v. 35	XXIV/35	Jebal At Tair	1	Red Sea
11. v. 35	XXV/35	Daedalus Reef	1	Red Sea
11. v. 35	XXVI/35	The Brothers	$1\frac{1}{4}$	Red Sea
11–12. v. 35	XXVII/35	Straits of Jubal and Gulf of Suez	$2\frac{1}{4}$	Red Sea
19. v. 35	XXVIII/35	Malta Channel	$1\frac{3}{4}$	—
20. v. 35	XXIX/35	Passing Cape Bon, Mediterranean	1	—
20. v. 35	XXX/35	Passing Cani Rocks, Mediterranean	2	—
20. v. 35	XXXI/35	Passing Pantellaria, Mediterranean	2	—
29. v. 35	XXXII/35	Approaching Cape St Vincent	2	—
30. v. 35	XXXIII/35	Off Cape Espichel	$1\frac{1}{4}$	—
30. v. 35	XXXIV/35	Passing The Burlings	$2\frac{1}{2}$	—
5. x. 35	XXXV/35	Across Hurd Deep	2	Near Channel Islands
10. x. 35	XXXVI/35	South from Ushant	$2\frac{1}{4}$	—
10. x. 35	XXXVII/35	North Coast of Spain	$5\frac{1}{4}$	—
10. x. 35	XXXVIII/35	Dacia Bank	3	—
28. xi. 35	XXXIX/35, XL/35	Across Kerguelen-Gaussberg Ridge	$7\frac{1}{2}$	(N.C.)
30. xii. 35	XLI/35	Approaching Foveaux Strait, New Zealand	$3\frac{1}{4}$	—
30–31. xii. 35	XLII/35	Foveaux Strait	10	—
10. i. 36	I/36	70° 55′ S, 178° 19·4′ W to 70° 59·7′ S, 178° 10′ W	1	Re-echoes
14. i. 36	II/36, III/36	72° 30·2′ S, 178° 03·2′ W to 73° 08·4′ S, 179° 52′ W	4	—
14. i. 36	IV/36	74° 17·1′ S, 179° 18·5′ E to 74° 44·8′ S, 179° 55′ E	3	—

APPENDIX II (*cont.*)

Date	Record No.	Locality	Run in hours	Remarks
16. i. 36	V/36 VI/36	78° 00·9′ S, 169° 04′ W to 78° 26′ S, 164° 11′ W	2	—
25. i. 36	VII/36	Off Ross Island	4¾	(N.C.)
26. i. 36	VIII/36	75° 39·2′ S, 173° 50′ E to 75° 22·3′ S, 176° 18·5′ E	4	—
2. ii. 36	IX/36	From approx. 66° 01′ S, 164° 45′ E towards Balleny Islands	3¾	Remainder undecipherable
3. ii. 36	X/36	Approaching the Balleny Islands	3¼	—
3. ii. 36	XI/36	Leaving the Balleny Islands	¾	—
5. ii. 36	XII/36	65° 32·9′ S, 160° 54·4′ E to 65° 14·7′ S, 160° 55·8′ E	1¾	—
18. v. 36	XIII/36	33° 50·5′ S, 17° 28′ E to 33° 50·4′ S, 17° 10·7′ E	1¾	—
19. v. 36	XIV/36	33° 50·5′ S, 14° 59·4′ E to 33° 50·4′ S, 14° 43·1′ E	1	2700 fm.
20. v. 36	XV/36	33° 42·5′ S, 10° 25′ E to 33° 41·6′ S, 10° 02·2′ E	2	2700 fm.
17. ix. 36	XVI/36	33° 54·4′ S, 11° 15·3′ E to 33° 54·3′ S, 11° 12·5′ E	¼	2600 fm.
19. ix. 36	XVII/36	33° 41·5′ S, 02° 12′ E to 33° 39·2′ S, 01° 29·9′ E	3½	(N.C.)
14. x. 36	XVIII/36	54° 20·9′ S, 35° 16′ W to 54° 27·6′ S, 35° 45·4′ W thence toward Cumberland Bay	9½	(N.C.). courses various approaching South Georgia
23. x. 36	XIX/36	Approaching Willis Island, South Georgia	4½	(N.C.)
12–13. xi. 36	XX/36	64° 01·4′ S, 53° 13·3′ W to 61° 20·8′ S, 54° 04·2′ W	17¼	(N.C.)
5. xii. 36	XXI/36	Approaching South Georgia from Port Stanley	6½	—
18. xii. 36	XXII/36	Round Willis Island to Undine Harbour, South Georgia	6¾	(N.C.)
19. xii. 36	XXIII/36	Undine Harbour to Bird Island, South Georgia	3	—
5. i. 37	I/37	Bridgeman Island to North Foreland, King George Island	3½	(N.C.) South Shetlands survey
6. i. 37	II/37	North Foreland to Penguin Island anchorage	4¼	(N.C.) South Shetlands survey
7. i. 37	III/37	Penguin Island to Lion's Rump, via Admiralty Bay	6	(N.C.) South Shetlands survey
9. i. 37	IV/37	Lion's Rump to Penguin Island	¾	South Shetlands survey
10. i. 37	V/37	Penguin Island to Lion's Rump	¾	South Shetlands survey
11. i. 37	VI/37	Lion's Rump to Penguin Island	2	St. 1952 intervenes. South Shetlands survey
12. i. 37	VII/37	Penguin Island to Lion's Rump	¾	South Shetlands survey
13. i. 37	VIII/37	Lion's Rump—Cape Melville—Lion's Rump	5	(N.C.) South Shetlands survey
14–15. i. 37	IX/37	Penguin Island to anchorage near Esther Harbour	8¼	(N.C.) South Shetlands survey
15. i. 37	X/37	Anchorage to Esther Harbour	1¾	South Shetlands survey
18. i. 37	XI/37	North Foreland—Bolinder Beach and to sea	7¼	(N.C.) South Shetlands survey
19. i. 37	XII/37	Towards anchorage, Penguin Island	5½	South Shetlands survey
20. i. 37	XIII/37	Penguin Island to Visca anchorage, Admiralty Bay	4	South Shetlands survey
22. i. 37	XIV/37	Visca Anchorage to North Foreland	10¾	South Shetlands survey
23. i. 37	XV/37	North Foreland to sea and hove-to	1½	South Shetlands survey
25. i. 37	XVI/37	Cape Melville to Admiralty Bay	6½	South Shetlands survey
28. i. 37	XVII/37	From approx. 61° 35′ S, 57° 23′ W	6½	(N.C.) See ship's log
30. i. 37	XVIII/37	Ridley Island to O'Brien Island	12	(N.C.)
31. i. 37	XIX/37	O'Brien Island—Gibbs Island—Aspland Island	9¾	—
1. ii. 37	XX/37	Off Gibbs and Aspland Islands, on survey	8	—
2. ii. 37	XXI/37	Off Gibbs Island and to Clarence Island	9	(N.C.)
4. ii. 37	XXII/37	Clarence Island to Cornwallis Island	5½	(N.C.)
6. ii. 37	XXIII/37	Approaching South Orkneys	4¾	See note on record re berg
11. ii. 37	XXIV/37	Scotia Bay to Graptolite Island	4	South Orkneys survey

APPENDIX II (*cont.*)

Date	Record No.	Locality	Run in hours	Remarks
12. ii. 37	XXV/37	Graptolite Island to Signy Island	13	South Orkneys survey
13. ii. 37	XXVI/37	Approaching and leaving Borge Bay	4¾	(N.C.) South Orkneys survey
14. ii. 37	XXVII/37	Approaching Sandefjord Bay	2	South Orkneys survey
15. ii. 37	XXVIII/37	Sandefjord Bay to North Coast Coronation Island	5½	(N.C.) South Orkneys survey. Very steep slope
21–22. iv. 37	XXIX/37	32° 53′ S, 00° 06·4′ W to 32° 02·2′ S, 00° 22·2′ W	4	Shallow ridge
13. x. 37	XXX/37	Josephine Bank	4¼	—
14. x. 37	XXXI/37	Approaching Madeira	2	—
19. x. 37	XXXII/37	Approaching St Vincent	1¾	—
1. xi. 37	XXXIII/37	Approx. 18° S, 3° E	1	(N.C.) 3000 fm.
3. xi. 37	XXXIV/37	Approx. 24° S, 9° E	1	2600 fm.
4. xi. 37	XXXV/37	Approx. 28° S, 12° E	1¼	2600 fm.
5. xi. 37	XXXVI/37	29° 05·2′ S, 13° 32·4′ E to 29° 34·5′ S, 14° 03′ E	4¼	—
29. xi. 37	XXXVII/37	57° 59·5′ S, 56° 00·8′ E to 58° 14·1′ S, 56° 43·1′ E	3	2900 fm.
30. xi. 37	XXXVIII/37	59° 31·2′ S, 60° 42·3′ E to 59° 42·3′ S, 61° 13·5′ E	2½	2900 fm.
1. xii. 37	XXXIX/37	60° 06·4′ S, 66° 17·3′ E to 60° 07·6′ S, 66° 58·5′ E	2¼	2600 fm.
3. xii. 37	XL/37	57° 26·6′ S, 74° 06·7′ E to 56° 18·2′ S, 76° 30·4′ E	12½	Kerguelen-Gaussberg Ridge
3–4. xii. 37	XLI/37 } XLII/37 }	56° 13·7′ S, 76° 39·2′ E to 56° 56·5′ S, 80° 28·7′ E	22	Kerguelen-Gaussberg Ridge: courses various, see ship's log
18–19. xii. 37	XLIII/37	Approaching Fremantle, West Australia	2¾	—
30. xii. 37	XLIV/37	34° 25′ S, 114° 35′ E to 35° 15·3′ S, 114° 45′ E	6	—
14. i. 38	I/38	61° 51·1′ S, 131° 04·6′ E to 61° 58·1′ S, 131° 18·8′ E	1¼	2400 fm.
15–16. i. 38	II/38	63° 53·1′ S, 135° 16·8′ E to 66° 13·8′ S, 139° 46·4′ E	23	(N.C.)
16. i. 38	III/38	66° 14′ S, 139° 50′ E to 65° 18′ S, 139° 10·6′ E	5	—
19. i. 38	IV/38	64° 15·6′ S, 153° 58′ E to 64° 26·7′ S, 154° 14·7′ E	1½	—
19. i. 38	V/38	66° 06·8′ S, 156° 42·2′ E to 66° 55·6′ S, 157° 59·5′ E	6	—
20–21. i. 38	VI/38	Balleny Islands	9½	See Text-fig. (N.C.)
21–22. i. 38	VII/38	Balleny Islands	13¾	See Text-fig.
26–27. i. 38	VIII/38	54° 59·3′ S, 167° 54·2′ E to 53° 46·2′ S, 168° 41·2′ E	9	—
27–28. i. 38	IX/38	52° 59·2′ S, 169° 00′ E to Campbell Island	7½	Includes harbour (N.C.)
7–8. ii. 38	X/38	Dunedin (N.Z.) to 46° 03·2′ S, 171° 22·5′ E	4	—
9–10. ii. 38	XI/38	Antipodes Island	4½	Circuit of island
26. ii. 38	XII/38	69° 11·8′ S, 123° 26·7′ W	½	Shallow soundings
14. iii. 38	XIII/38	55° 35′ S, 60° 14′ W to 54° 44·8′ S, 59° 36·8′ W	4	Burdwood Bank
28. iii. 38	XIV/38	55° 32·1′ S, 36° 07·4′ W to South Georgia	3¼	—
19. iv. 38	XV/38	64° 47·3′ S, 07° 37·8′ E to 64° 48·5′ S, 08° 02·1′ E	1	2400 fm.
7. vii. 38	XVI/38	41° 54·2′ S, 01° 17′ E to 42° 20·1′ S, 01° 18·7′ E	2½	Discovery Bank
10. vii. 38	XVII/38	50° 53·1′ S, 00° 27·7′ E to 51° 02·2′ S, 00° 26·4′ E	1	Shallow soundings
25. vii. 38	XVIII/38	41° 25·2′ S, 19° 32·2′ E to 41° 09·6′ S, 19° 27·9′ E	1½	2900–2700 fm.
11. viii. 38	XIX/38	41° 52·1′ S, 00° 18·2′ E to 42° 19·3′ S, 00° 17·8′ E	3	Discovery Bank
16. viii. 38	XX/38	54° 30′ S, 00° 15·7′ E to 54° 50·3′ S, 00° 17·4′ E	2	Shallow soundings
20. ix. 38	XXI/38	41° 57′ S, 00° 38′ E to 42° 12·7′ S, 00° 39′ E	1½	Discovery Bank
23. x. 38	XXII/38	41° 50·5′ S, 01° 17·4′ E to 42° 09·9′ S, 01° 20·5′ E	3	(N.C.) Discovery Bank
28. x. 38	XXIV/38	54° 58·8′ S, 02° 14·9′ E to 54° 45·8′ S, 02° 33·4′ E	2¾	Bouvet Island
28. x. 38	XXV/38	54° 38·4′ S, 02° 39·9′ E to 54° 19′ S, 03° 25′ E	4	(N.C.) Bouvet Island
29. xi. 38	XXVI/38	42° 02·6′ S, 00° 55·4′ W to 42° 04·9′ S, 00° 48·6′ E	9	Discovery Bank (W to E)
9. i. 39	I/39	35° 58·8′ S, 11° 42·5′ E to 36° 08·3′ S, 11° 13·4′ E	2½	2700 fm.
17. i. 39	II/39	Bouvet Island	4	(N.C.)
21–22. i. 39	III/39	68° 50·2′ S, 02° 05·4′ E to 69° 37·9′ S, 02° 07·8′ E	4½	(N.C.) Approaching Continental Shelf
29. i. 39	IV/39	62° 33·9′ S, 19° 43·3′ E to 62° 24·3′ S, 19° 44·1′ E	1	2700 fm.
21. ii. 39	V/39	41° 40·8′ S, 00° 48·2′ E to 42° 31·7′ S, 00° 50′ E	5½	Discovery Bank
24. ii. 39	VI/39	{ 51° 07·6′ S, 01° 06′ E to 51° 17′ S, 01° 06′ E 51° 35′ S, 01° 04·4′ E to 51° 43·1′ S, 01° 03·7′ E	1 } 1 }	Shallow soundings
4. iii. 39	VII/39	69° 14·8′ S, 00° 18·2′ E to Barrier and thence along coast of continent to 69° 47·8′ S, 02° 21·1′ E	15 }	Courses various, see sounding log for details
5. iii. 39	VIII/39	Continuing along coast of continent	13 }	

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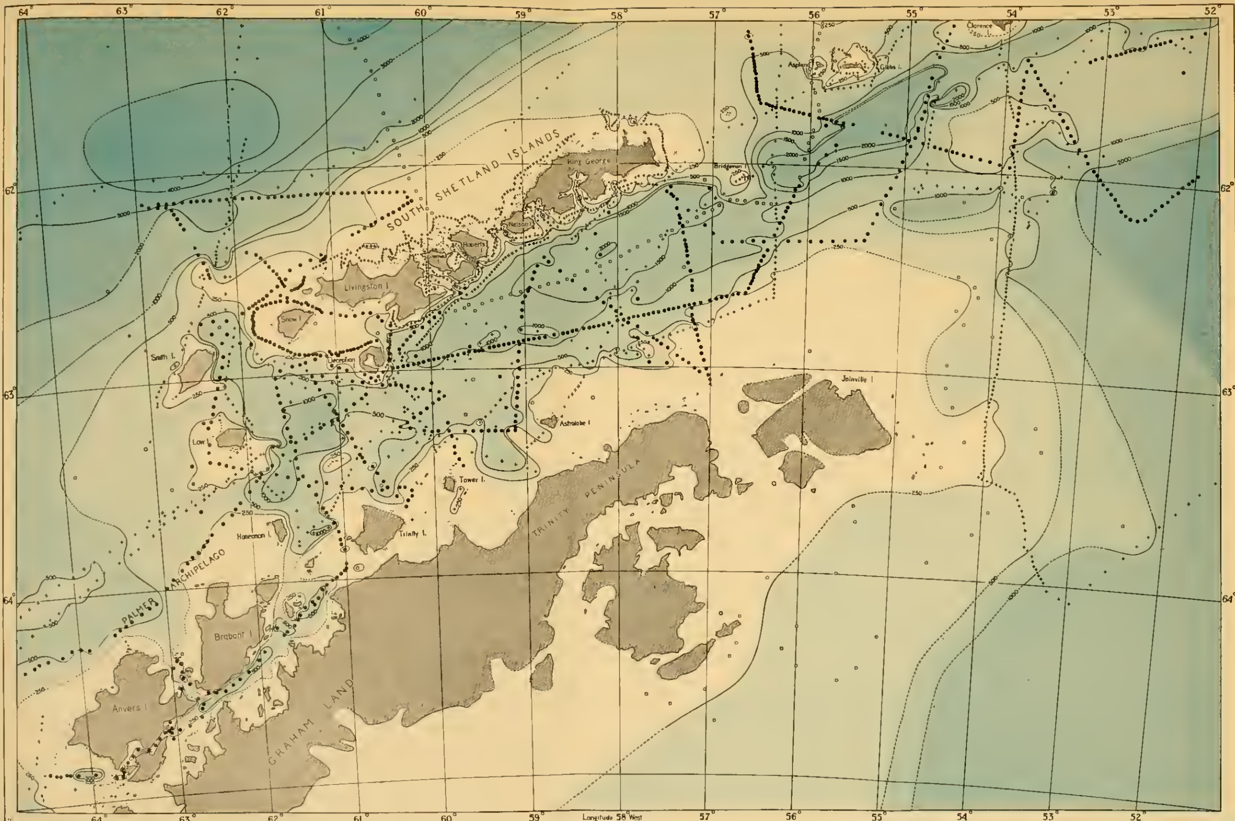
NOTE ON THE PLATES

Plates XXVI–XXXI are collotype reproductions of selected sections of sounding records, all reduced to one-half the original size. The order of sounding is from left to right. In colour and intensity they approximate to the originals, which vary a little in these respects. Reproduction has involved a slight loss of contrast but virtually no loss of detail. Even where the line of the sea floor becomes confused and lost, almost no details can be seen in the originals which cannot be seen in the collotypes.

THE SCOTIA SEA

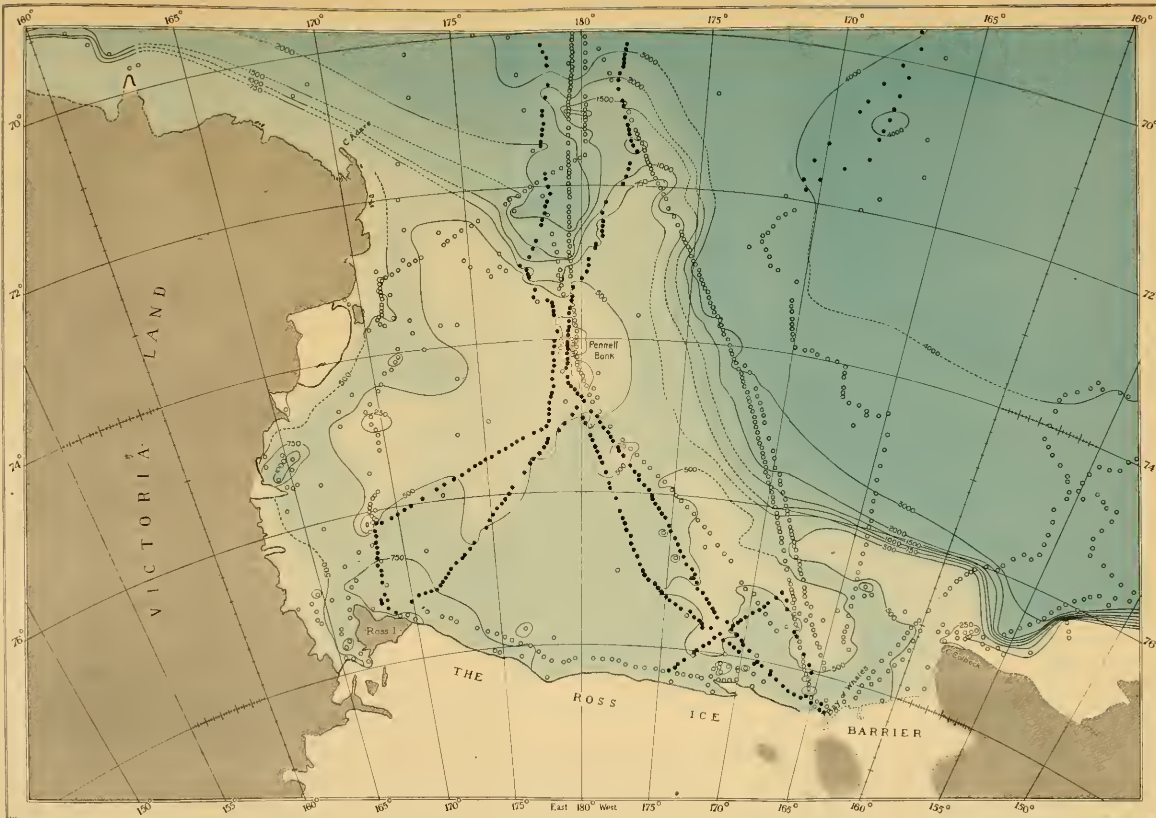
The positions of soundings taken by the Discovery Investigations prior to May, 1932, are shown as black dots; the positions of those taken subsequently are marked with crosses. Soundings from other sources are shown as circles



Printed by John Bartholomew & Son Ltd, Edinburgh

THE BRANSFIELD STRAIT AND ADJACENT WATERS

The positions of soundings taken by the Discovery Investigations prior to May, 1932, are shown as black dots; the positions of those taken subsequently are marked with crosses. Soundings from other sources are shown as circles.



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THE ROSS SEA

The positions of soundings taken by the Discovery Investigations are shown in black. Soundings from other sources are shown as circles

PLATE XXVI

Fig. 1. Slope of bottom north from Coronation Island, South Orkneys. Phasing by 100 fathom steps. Speed of ship, 9 knots. Vertical scale, $\times 9\cdot72$. From 60° 26′ S, 45° 55·5′ W to 60° 21·5′ S, 45° 59·3′ W. (Part of Record XXVIII/37.) See Text-figs. 3 (*c*), p. 46, and 13, p. 66.

Fig. 2. Slope of bottom approaching Falmouth Bay, Tristan da Cunha, from the North. Phasing by 200 fathom steps. Speed of ship, 9·5 knots. Vertical scale, $\times 10\cdot26$. From 36° 56·8′ S, 12° 19·3′ W to anchorage at Falmouth Bay. (Part of Record IV/33.) See Text-figs. 3 (*a*), p. 46, and 9, p. 55.

Fig. 3. Approaching Antarctica in the meridian of Greenwich; confused bottom at 900 to 1000 fm. (1646 to 1829 m.), followed by a steady rise to a depth of 170 fm. (311 m.) close to land. Virtually no continental shelf. Speed of ship, 9 knots. Vertical scale, $\times 9\cdot72$. From 69° 37·4′ S, 00° 41′ E to 69° 43·6′ S, 00° 50·3′ E. (Part of Record VII/39.) See Text-figs. 2 (*a*), p. 45, and 17, p. 88.

Fig. 2

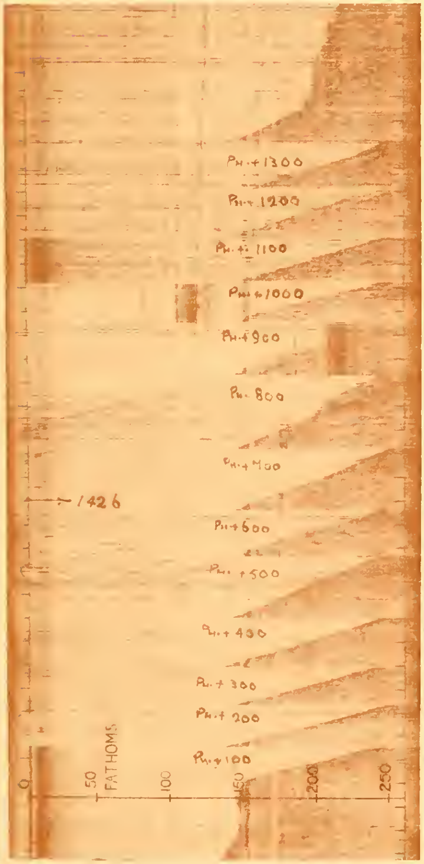

Fig. 1

Fig. 3

PLATE XXVII

Fig. 1. Varied bottom, at depths between 125 and 340 fm. (229 and 622 m.) in the Schollaert Channel, Palmer Archipelago. Speed of ship shown on record. Vertical scales: at 3 knots, × 3·24; at 9 knots, × 9·72. Note interference to the mains supply caused by induced current from ship's W/T apparatus. (Part of Record XV/34.)

Fig. 2. Moderately irregular bottom in the Bransfield Strait, South Shetlands, on a course from Fildes Strait to Deception Island. Section of record shown lies about 4 miles south-east of the coast of Roberts Island. Speed of ship, *ca.* 3·5 knots. Vertical scale, × *ca.* 3·8. (Part of Record XXVII/34.) See Text-fig. 4 (*b*), p. 47.


FATHOMS
100
150
200
250
300
350
9 knots
3 knots
Speed - 9 knots

Fig. 1


FATHOMS
150
200
250

Fig. 2

PLATE XXVIII

Fig. 1. Approaching Adélie Land from the north-west. This recording shows the complicated structure of the bottom at depths between 1170 and 1320 fm. (2140 and 2414 m.), at the point where the steeper slope up to the continental shelf begins. Speed of ship, 9·5 knots. Vertical scale, × 10·26. From 64° 56′ S, 137° 38′ E to 65° 04′ S, 137° 50′ E. (Part of Record II/38.) See Text-figs. 1 (*b*), p. 44, and 17, p. 88.

Fig. 2. Complicated slope from coastal shelf to deeper water, off Otago Harbour, New Zealand. Record begins at 230 fm. (421 m.), on change over from shallow water set and records a maximum depth of 600 fm. (1097 m.). Speed of ship, 9·65 knots. Vertical scale, × 10·42. From 45° 50·4′ S, 171° 04·4′ E to 45° 58·2′ S, 171° 13′ E. (Part of Record X/38.) See Text-fig. 2 (*b*), p. 45.

Fig. 1

Fig. 2

PLATE XXIX

Fig. 1. Extremely irregular bottom recorded when approaching Bouvet Island from the south-west. Speed of ship, 10 knots. Vertical scale, $\times$ 10·8. From 54° 33·4′ S, 02° 50·3′ E to 54° 27·1′ S, 03° 04′ E. (Part of Record XXV/38.) See Text-fig. 2 (*a*), p. 45.

This is a typical example of the difficulties met in obtaining echo soundings from moderate depths on the line between the latitude of 40° S and the ice-edge, on the meridian of Greenwich. On this occasion conditions were good since the sea was calm, wind only force 2 and there was little swell.

Fig. 2. Irregular bottom at depths varying between 1220 and 1450 fm. (2231 and 2652 m.) on the outer slope of the Scotia Arc, 75 miles NW $\times$ W of Bird Island, South Georgia. Speed of ship, 8 knots. Vertical scale, $\times$ 8·64. From 53° 59′ S, 39° 54′ W to 53° 28·3′ S, 40° 00·8′ W. (Part of Record IX/34.) See Text-fig. 5(*b*), p. 49.

Fig. 3. Passing Europa Island, Mozambique Channel. Irregular bottom and moderate slope. Soundings range between 406 and 1000 fm. (742 and 1829 m.). Speed of ship, 8·8 knots. Vertical scale, $\times$ 9·5. From 22° 24·7′ S, 40° 26·8′ E to 22° 18·2′ S, 40° 28·8′ E. (Part of Record XIX/35.)

Fig. 1

Fig. 3

Fig. 2

PLATE XXX

Fig. 1. Passage from open water through brash ice and loose pack, off the ice barrier in Long. 1° E. Sea, calm; wind, force 2. Speed of ship, 9 knots. Vertical scale, ×9·72. In loose pack the echo, even at this shallow depth, is almost obliterated by the noises set up by the scraping of ice across the face of the hydrophone. This record shows part of the sea floor which is relatively free from irregularities. Position (at 1030 hr.) 69° 50·2 'S, 00° 56·7' E. (Part of Record VII/39.) See Text-fig. 2 (*a*), p. 45.

Fig. 2. Re-echoes at 1780–2000 fm. (3255–3658 m.) from soundings between 890 and 1000 fm. (1628 and 1829 m.) during the survey of Clarence Island. Speed of ship, *ca.* 4·5 knots. Vertical scale, ×*ca.* 4·9. (Part of Record XXVIII/37.) See Text-fig. 3 (*c*), p. 46.

Fig. 3. Section of record showing the effect of a rising wind and sea on the echo, at a depth of approximately 270 fm. (494 m.), on the Discovery Bank. Section begins with recording at a speed of ship of 2 knots, which increases to 8·5 knots at the point indicated. Wind was NW, 22–27 knots and sea, NW, force 5; there was also a moderate North-westerly swell. Ship's course, W. Weather was deteriorating rapidly. Vertical scales: at 2 knots, ×2·16; at 8·5 knots, ×9·18. From 42° 03·9' S, 00° 03·5' E to 42° 04·1' S, 00° 11' E. (Part of Record XXVI/38.) See Text-fig. 2 (*a*), p. 45.

Fig. 4. Simple 'crossover' at a depth of 215 fm. (393 m.). Speed of ship, 9·5 knots. Vertical scale, ×10·26. Position, approx., 14 miles N 63° W of C. Finisterre.

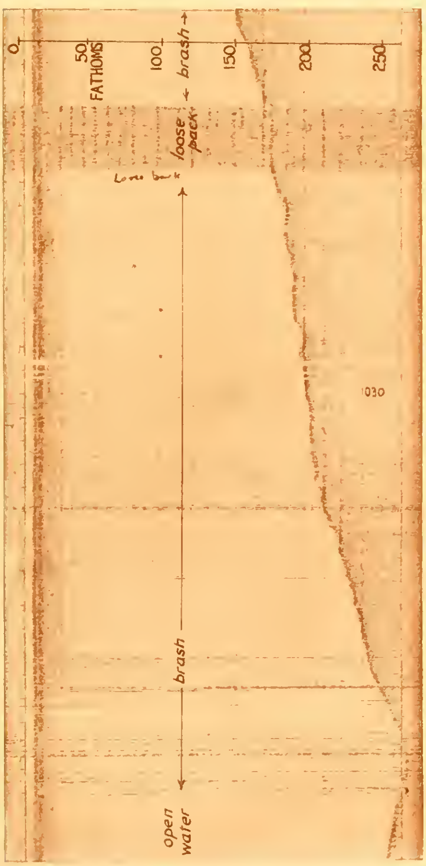

Fig. 1

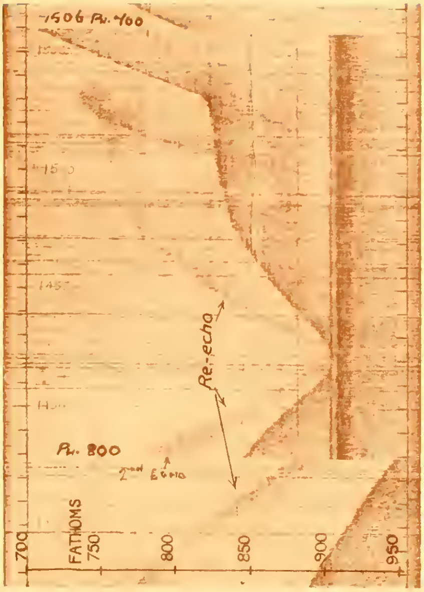

Fig. 2

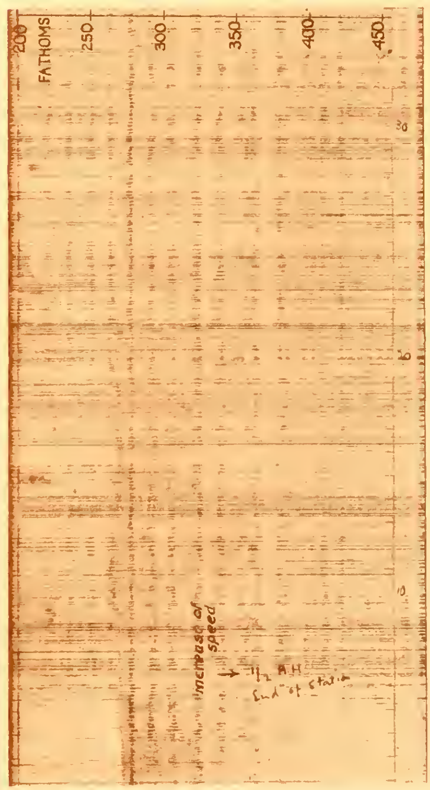

Fig. 3

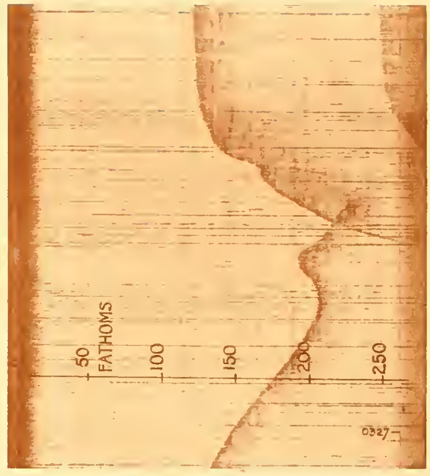

Fig. 4

PLATE XXXI

Fig. 1. Example of the elimination of the transmission band, by means of the 'cut-out' switch, to allow the echo to be recorded at depths varying between 990 and 1210 fm. (1810 and 2213 m.). In this instance a fault in the transmission, known as 'double-knocking', also is seen recorded. This trouble normally was caused by the lack of sufficient 'back-pressure' through the reducing valve, which prevented the sharp return of the hammer to the magnetic valve. It could also be caused by the partial failure of the magnetic air valve in the head of the hammer, when a second blow would be struck before the supply of H.P. air was properly cut off. Speed of ship, 10 knots. Vertical scale. × 10·8. (Part of Record XXXVI/37.)

Fig. 2. Typical record from M/S. XII type shallow water recorder. Record made during survey of NW coast of Coronation Island, South Orkneys, in 1937. Pencil markings were inserted as soon as the record was dry, in order to facilitate the plotting of the soundings should the record fade. Time scale automatically marked every 3 minutes. Speed of ship, 7 knots. Vertical scale, × 7·56. (Part of Record XXVIII/37.) See Text-fig. 3(*c*), p. 46.

Fig. 1

Fig. 2

ON THE REPRODUCTIVE ORGANS OF *HOLOZOA CYLINDRICA* LESSON

By Dr A. Ärnbäck Christie-Linde

(Plate XXXII)

In the Magellan region Lesson (in 1830) collected a peculiar Polycitorid species of Ascidian which he described under the name of *Holozoa cylindrica*.

This find was long forgotten, and when several specimens were later collected in Antarctic waters, this same species was described under different generic and specific names. This fact has been pointed out by previous authors. Calman's *Julinia australis* and Herdman's *Distaplia ignota*, likewise Sluiter's *Julinia ignota*, which have all been collected in the Antarctic, are no doubt representatives of *Holozoa cylindrica*.

With regard to the external form and shape of the colonies, as well as of the zooids, the previous descriptions agree in essential points. I will return to a discussion of this matter in another paper, in which additional comments may be made. The reproductive organs only will be dealt with in this preliminary note.

The common view is that the colonies and the zooids in them are gonochoristic, i.e. either male or female. But Calman's statement (1895) as to this character is not quite clear. He writes: 'In all the individuals examined several ova were found in various stages of development...' (loc. cit. p. 10); and further at the bottom of the same page: 'In nearly all the specimens examined hardly a trace of testis could be found, although the vas deferens was usually full of spermatozoa. In one or two cases, however, the testis was developed' (p. 11). And further, on the same page: 'No definite relation between the states of maturity of ovary and testis such as would suggest the occurrence of protandry or protogyny could be demonstrated.'

Michaelsen has pointed out that Herdman's *Distaplia ignota* is no doubt identical with *H. cylindrica* Lesson, though he has accepted the generic name *Julinia* proposed by Calman. He writes in his description that the colonies of the species in question seem to be either male or female. '*Julinia* scheint wie *Colella*—getrennt geschlechtliche Kolonien zu produzieren' (1907, p. 41).

Hartmeyer, too, is of the same opinion. He has had abundant material at his disposal, and the result of his investigation is that the colonies examined by him are gonochoristic.

With regard to Calman's description Hartmeyer (1911) remarks: 'Immerhin scheint mir nach allem, was Calman über die Geschlechtsorgane sagt, sein Material nicht günstig genug gewesen zu sein, um aus seinen Beobachtungen einen sicher begründeten Einwand gegen die von Michaelsen und mir auf Grund gewichtigen Tatsachenmaterials angenommene Eingeschlechtlichkeit der Kolonien herzuleiten' (loc. cit. p. 484).

I now have reason to return to the subject, having had occasion to examine colonies of *Holozoa cylindrica* collected by the Discovery Expeditions and also a few colonies brought back by the British Graham Land Expedition (with the 'Penola'). The Discovery material was taken by dredge in the mouth of East Cumberland Bay, South Georgia, 200–234 m. (St. 149), 10 January 1927, and that from the British Graham Land Expedition was taken at Stella Creek, surface, 5 December 1935.

The result of this investigation refutes the above-mentioned view of Hartmeyer and Michaelsen, and gives proofs for an opinion opposite to that of these authors, for, as will be shown below, the species in question prove to be hermaphrodite.

The figures given here (Plate XXXII) of zooids from the above-mentioned material support in an indisputable way the view of the hermaphroditism of *H. cylindrica*. As is shown in Plate XXXII, fig. 1, illustrating an individual from a colony collected by the Discovery Expedition, in January, the female and the male reproductive organs are both present. They are situated on the right side of the body, on the bend of the intestine. The testis is placed to the side of the ovary. A large brood-pouch is developed on the dorsal side of the thorax.

In the zooid figured the ovary consists of two large eggs. In some zooids two to three large eggs have been observed at the same time. The oviduct is thin-walled, long and broad, running along the ascending part of the intestine. The distal part is narrow. In the figure the oviduct is seen entering into the brood-pouch with its distal narrow part. As mentioned above, the brood-pouch is well developed. It is in the form of a large rounded sac.

The testis is well distinguished, though not very much developed in the individual in question. It consists of small rounded glands, which seem more or less emptied of their contents. The vas deferens is represented by a wide duct of considerable length and with several windings. It is situated on the external side of the oviduct and runs up along the intestine and the rectum. It opens at the side of the anus, and its distal part is seen in the figure given.

The individual illustrated in Plate XXXII, fig. 2, is from a colony dredged by the British Graham Land Expedition at Stella Creek, in December. In this zooid the male reproductive organs are in a highly developed stage. The testis consists of a great number of glands, of rounded or oval shape, forming a large mass of mulberry-like aspect. The vas deferens is still a narrow tube, sinuous, but shorter, being without the deep windings seen in the Discovery sample described above. It accompanies the ascending branch of the intestine.

Of the female reproductive organs, however, only rudimental traces are to be seen. Three small follicles of whitish colour situated on the external side of the testis (cf. Plate XXXII, fig. 2) represent no doubt the ovary. The oviduct could not be distinguished. A rudiment of the brood-pouch is distinctly to be seen, though it is only little developed.

The facts pointed out above prove that *H. cylindrica* is hermaphrodite. The colonies and the zooids are not either male or female, as is the view of several previous authors. But whether the male and the female reproductive organs attain their full development at the same time or at different seasons is another problem.

If we consider the states of maturity of the reproductive organs in the zooids figured and the difference in season when the material was collected, certain conclusions may be justified.

The zooid shown in Plate XXXII, fig. 2, is from a colony taken in December, the last month of the year, i.e. early in the Antarctic summer. The zooid shown in fig. 1 is from a colony taken in January, the first month of the year, i.e. in the full summer in the Antarctic region.

In the first-mentioned individual the male reproductive organs are highly developed, and the testis seems to have attained its full maturity. The vas deferens is a long sinuous tube. The female reproductive organs are in a rudimentary stage. The ovary is represented by three small ova, and the oviduct is not to be seen. The rudiment of the brood-pouch is in the form of a small vesicle.

In the individual from the colony dredged in the Antarctic summer the female reproductive organs are in their full development. The ovary consists of large ova, the oviduct is distinctly differentiated, and the brood-pouch is represented by a large rounded vesicle attached to the body by means of a narrow neck. The male reproductive organs seem to be in a reduced stage. The testis consists of a small number of thin follicles lying at the side of the ovary, but the vas deferens is still a duct of great length and width, winding up along the intestine and the rectum.

From the state of maturity of the reproductive organs mentioned above it is apparent that the male

organs attain their full development early in the Antarctic summer, and the female organs later during the full Antarctic summer. The former are thus mature in advance of the female. The conclusion which might be drawn from these facts seems thus to point to the occurrence of protandry in *H. cylindrica.*

According to Hartmeyer and Michaelsen, and also Van Name (1945) other Polycitorid genera too, for instance *Sycozoa* and *Sigillina*, are gonochoristic, the colonies and the zooids from the same colony being either male or female (see Bronn's Tier-Reich). The fact that *Holozoa cylindrica* is hermaphrodite raises the question whether these genera in fact also possess this peculiar character.

In his paper *Ascidiae Krikobranchiae von Neuseeland, den Chatham- und den Auckland-Inseln* (1924), Michaelsen has in some degree receded from this opinion. In the above-mentioned paper of his he proposes to unite the nearly allied forms *Holozoa* and certain species of *Sycozoa* under a common generic name *Distaplia.—Holozoa* and *Distaplia* are considered by Hartmeyer as identical (loc. cit. p. 1437).—In his diagnosis of the genus *Distaplia* Michaelsen mentions as one of the generic characters 'Personen zwittrig oder Kolonien getrennt geschlechtlich; ein enggestielter Brutsack vorhanden, 1 Embryo oder deren mehrere enthaltend' (loc. cit. p. 297). 'In der Gattung *Distaplia* s.s. kommen dagegen sowohl Arten mit getrenntgeschlechtlichen Kolonien vor, sowie solche mit Kolonien, deren Personen zwittrig sind' (loc. cit. p. 321). According to this author the species of this genus are thus either gonochoristic or hermaphrodite. In *Distaplia* (*Holozoa*) *cylindrica* and the 'cerebriforme-Gruppe', the colonies and the zooids are of the same sex, but in other species of *Distaplia* they are hermaphrodite.

Taking into consideration what has been adduced above, it is evident that until further evidence is forthcoming by way of thorough investigations nothing can be stated for certain, whether certain Polycitorid forms are in reality gonochoristic, or whether, just as in *Holozoa*, an investigation of suitable material collected in various seasons might prove them to be hermaphrodite.

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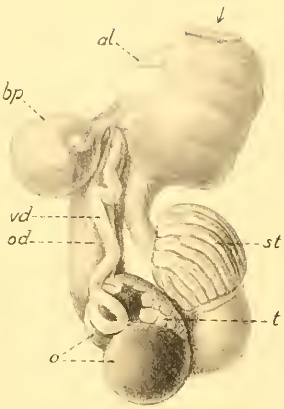
PLATE XXXII

Fig. 1. *Holozoa cylindrica.* Zooid, seen from the right side. × 18. *al*, atrial languet; *bp*, brood-pouch; *o*, ovary; *od*, oviduct; *st*, stomach; *t*, testis; *vd*, vas deferens.

Fig. 2. *H. cylindrica.* Zooid, seen from the right side. × 18. *al*, atrial languet; *bp*, brood-pouch; *o*, ovary; *st*, stomach; *t*, testis; *vd*, vas deferens.



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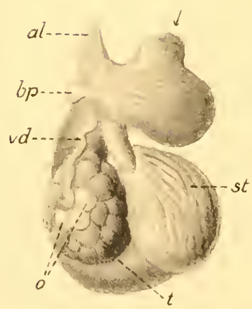

2

HOLOZOA CYLINDRICA LESSON

THE HABITS OF FIN WHALES[1]

By E. R. Gunther

(Plate XXXIII; Text-figs. 1–7)

INTRODUCTION

In the present paper various observations of whales, as they have been seen at sea, have been put together in the hope that they will contribute to a broader understanding of the relations of the living whale to its environment. The observations were made from a modern whale catcher, the *Skua*, while engaged upon whale-marking work[2] in the neighbourhood of South Georgia during the two months 11 December 1936 to 9 February 1937. The author had a stop-watch but no cinematograph camera, and in consequence many of the conclusions made in the following pages are open to amendment.

The difficulties of making observations on living whales are many. They show themselves above water for only brief periods, and their specialization for life in the water renders direct comparison with the behaviour of land mammals hazardous. Opportunities of watching them at close quarters have usually been restricted to vessels engaged in whaling; on board which life has to be lived to be understood. True (1903), who has used a camera on board a catcher, has remarked '...the difficulty of getting the picture itself is so great that one's faculties are entirely absorbed in the proceeding and there is little opportunity for observing particulars. The pitching and rolling of the steamer in the restless waters is very disconcerting, and not less so the fact that the point at which the whale will appear is uncertain and the length of time it will remain in view very brief.' It is noteworthy that True's photographs were secured in calm weather.

A research ship has certain advantages over the commercial catcher. She is on the whaling grounds for longer periods, and when following a school, the chase does not terminate when one whale has been hit. While the firing of marking guns has a disturbing effect upon whales, the noise is not to be compared with the report of a commercial harpoon gun and probably gives correspondingly less shock. The motion of a catcher is, of course, the same whether she is actually used for catching whales or not. She completes a roll in 4 sec. and this means that the opportunity to fire marks occurs momentarily every 2 sec. when the ship is either at the crest or the trough. Another factor making for great difficulty in the collection of scientific data in the Sub-Antarctic is the incessant spraying of cold water over the gun platform so that on many days it is impossible to use pencil and paper.

The report is divided into three parts and it concerns only the habits of the Fin whale (*Balaenoptera*

[1] This paper was nearly completed by the late Mr Gunther in 1939. His death on active service, however, took place in 1940, and the MS. was not available until after the war. The text and illustrations are printed almost as he left them, except for two passages which seemed to need revision. Thus the first sentence has been written in place of three short opening paragraphs, and on p. 121 the two paragraphs beginning, 'Over all the periods of observation...', and ending, 'breathing intervals of different whales', replace a passage equivalent to rather less than a page of text (together with three text-figures) in which the data on the frequency of blowing were further discussed. It is believed that these two paragraphs summarize the author's line of thought. He could no doubt have adjusted both the original passages by a few amendments, but to revise them now in full might involve a departure from his intentions. Elsewhere in the text only trivial editorial work has been needed. Among the illustrations the author had provisionally chosen nine photographs. Of these the six reproduced in Plate XXXIII are the most suitable for reproduction and seem to meet the author's requirements.—*Ed.*

[2] See Rayner, 1940.

physalus). Part I, as far as permitted by the nature of the observations, is an account of the whales as they have been seen at the surface. Inferences of what goes on below the surface, and comparisons with the observations of earlier authors, are left as far as possible until Parts II and III.

I. APPEARANCE AT THE SURFACE

Opportunities of observing cetacea occur both when they are under water near the surface and when they break surface to blow.[1] They have also been known to break surface without blowing. As, however, they are usually blowing when they are seen, it will be convenient first to consider various ways in which they come up to breathe.

Breaking surface to breathe

The length of time a mature Fin whale shows above water usually varies from 3 to 6 sec. and sometimes lasts for as long as $7\frac{1}{2}$ sec.; calves show for shorter periods of $2-2\frac{1}{2}$ sec. The time is divisible into two periods: the first a very short period of little more than 1 sec. during which the head emerges and submerges again, and then a period of variable duration, of from 2 to $6\frac{1}{2}$ sec. during which the rest of the body follows. The first period seems to vary comparatively little. The length of time the whale shows above water depends then mainly upon the length of the second period, and this depends very largely on what he is doing.

For simplicity of treatment three examples may be chosen to illustrate the different methods employed in breaking surface. They are discussed in later pages but it may be well here to bear in mind that no one of the methods need be rigidly adhered to.

(i) *Slow.* A whale breaking surface to blow very leisurely, approaches the surface horizontally and swims slowly (Fig. 1*a*). Its upward motion, in a more or less horizontal position, resembles the action of a submarine and can be watched for several seconds before it breaks the surface. The head and back break surface almost simultaneously and the whale blows. At the slowest speed the snout seems mostly to remain beneath the surface. The blowing over, the head is lowered as the dorsal fin emerges, so that for a split second both show above water (Fig. 1*b*; Pl. XXXIII, figs. 1, 2). The whole body then sinks, and the whale, still comparatively horizontal, submerges. This leisurely blowing ($7\frac{1}{2}$ sec.) gives a smaller target than the hurried movement.

(ii) *Medium speed.* Whales may be considered to be breaking surface at medium speed ($5\frac{1}{2}-6\frac{1}{2}$ sec.) when, as frequently happens, they approach the surface at an angle of $25-35°$; in this action they can also be seen for some moments before emergence and at this angle their attitude bears some resemblance to a tadpole gulping air at the surface of a pond. The tip of the snout is first seen and an appreciable extent (say one-third to one-half or more) of the lower jaw emerges (fig. 1*d*, *e*, and also True, 1903, plate XXIV, fig. 2). In head-on view the white chin and the ventral grooves are plainly visible from the catcher's bows. As soon as the blowhole is free the whale blows; but as it does so the head is dipped. As the head becomes horizontal, the upper jaw and, if visible, the whale-bone plates, are above the surface but the lower jaw is awash. The eye appears to be hidden by the wash which the lower jaw sets up. Further dipping of the head bends the anterior part of the body into an arc and as the whale moves forward the blowhole disappears from view (Fig. 1*f*, *g*; Plate XXXIII, figs. 3, 4). All this has happened in a surprisingly short time and constitutes stage 1.

The tip of the dorsal fin may break surface before the back is wholly out of the water, but the fin and blowhole are seldom visible together (Fig. 1*g*). The whale illustrated in Plate XXXIII, fig. 1, while showing both blowhole, fin and peduncle, appears to be swimming more horizontally and rather

[1] The word 'blow' is used throughout this account for the act of expiration and inspiration. It is synonymous with 'spout' which, however, is open to confusion with the traditional idea of a spouting column of water.

slower than the whale in fig. 2 of the same plate. As a result of further flexure, which can sometimes be seen to be effected by muscles of the back, the mid part of the body travels through the arc set by the head and neck (Fig. 1 *h*). As the whale travels forward, the trunk and fin rise out of the water (Fig. 1 *i*, and *j*); then, giving place to the caudal peduncle, the trunk begins to sink (Fig. 1 *k*, *l*). The general effect after the dipping of the head is that of a wheeling motion of the back out of the sea and into it again. But the fin, having wheeled out of the water, acquires a cam-like action and having reached its zenith, the wheeling motion stops. The outstanding parts now slowly sink, travelling forwards slowly. The caudal peduncle submerges, together with the posterior part of the trunk, and the fin is generally the last to disappear from view (Fig. 1 *m*). The fin and caudal peduncle often disappear simultaneously, but the peduncle seldom by itself and then only when the angle of diving is unusually steep. A whale blowing in this manner offers the best target not only because the movement is comparatively slow but also because the head, trunk and caudal peduncle are well elevated.

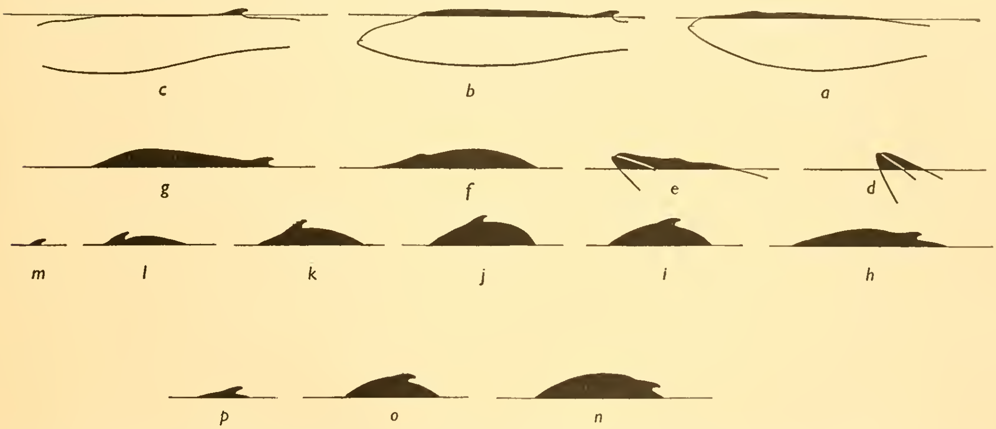

Fig. 1. Diagrams illustrating the appearances of Fin whales at the surface; based on photographs and notes, and on a drawing by J. F. G. Wheeler (Mackintosh and Wheeler, 1929). *a–c*, whale blowing leisurely; *d–m*, at medium speed; *n–p*, fast.

The whale may go through these motions faster or slower, a period of $4\frac{1}{2}$–6 sec. elapsing between the act of blowing and the disappearance of the dorsal fin ($5\frac{1}{2}$–7 sec. overall). A whale in a hurry blows off air before reaching the surface and a dome of silvery bubbles momentarily appears over the back of the neck. According to the speed of blowing depends the splash. A whale shooting its head out of the water fast, sometimes lets it down fast and the surface splash, accompanied by waves, spreads several yards to right and left. Disappearance of the fin and caudal peduncle, however, is unattended by splash.

Here it may be convenient to refer to the so-called 'oily patch' (or 'slick', True, 1903) left by the whales at the surface after their disappearance. The smoothness of these patches resembles closely the wake of a steamship, and the welling which is observed in them is doubtless produced by the tail flukes and affords useful evidence of their action.

(iii) *Fast*. When blowing is brisk, the whale appears and disappears so quickly (3–$3\frac{1}{2}$ sec.) that the details of its movement are hard to pick up and whales breaking surface in this way have not, during this whale-marking commission, been spotted beneath the surface beforehand. The whale appears suddenly and simultaneously blows. The tip of the snout is again the first part to emerge and the head shows above water for little more than a second as before. The movements are probably similar to those undergone in breaking surface at medium speed, but carried out with greater impetus. The body

is thrown into an arc of small radius and moves high out of the water so that an unusual depth of flank is momentarily visible (Fig. 1 *n*; Plate XXXIII, fig. 5). The amount of wheeling motion appears to be curtailed and the downward sinking comes on sooner, sometimes with lateral splashing. The fin and caudal peduncle are again the last to disappear (Fig. 1 *o*, *p*).

Breaking surface without breathing

On various occasions whales have been seen to break surface without blowing. On 22 December, the dorsal fins of two were seen above the water. The whales were leisurely, and on approach of the ship the fins submerged slowly. On 11 January, while whales were feeding upon krill close to the surface, tail flukes (either right or left) and flippers often broke surface, and the former waved in the air as though in execution of swimming movements. The significance of this will be referred to in the notes upon feeding (pp. 124 and 133). On 31 January a whale beneath the surface, a point or two off the course, made straight for the ship's stem and only averted collision by a sudden dive beneath the keel when a yard or two away. As he did so, the dorsal fin and the caudal peduncle were momentarily thrust out of the water. On 7 February, two other whales broke surface in much the same way. One showed the caudal pendunclc as it dived; the other seemed to be on the point of blowing but apparently changed its mind, the head and neck broke surface in the act of dipping, but most of the back remained covered.

Swimming

A view of whales swimming close to the surface is usually distorted by waves and wavelets, and the movements are hard to determine. As in their other activities, the larger rorquals look stately when they swim because of a majestic ease of motion, even when they are keeping abreast of a ship steaming at 10–12 knots. Seen from above, the flippers slope backwards but are spread out from the sides.

An idea of the rhythm of the tail flukes could be formed if it were possible to measure the distance between the 'oily patches'. It will be remembered that these are produced from the action of the flukes through the upward gush of water. At speeds of 10–12 knots, these patches appeared to be separated by 5–10 yards and as many as six or ten in series sometimes became visible when a whale was near the surface. According to these data, which are very rough, the flukes beat once every 1 or 2 sec. When a fluke is waved from side to side above the surface of the water, its rhythm appears rather faster but was not timed.

No whale was seen to swim twice as fast as the ship at full speed. The *Skua* was not able to steam faster than 12 knots, but the whales seemed, on occasion, to spurt half as fast again, and this would bring their speed for short distances up to 16–18 knots.

Frequency of blowing

Data on respiratory rhythm have been collected by timing the blowing of whales with a stop-watch. As often as opportunity offered, the observations were taken in unbroken series but often they had to be curtailed and then they consisted of no more than one or a few breathing intervals. Thus the observations may be looked upon as of two kinds, A and B. The first (A) at a distance from the ship spread over longer periods and the second (B) of supplementary observations on individual whales nearer the ship.

In the serial observations A, the stop-watch was started at the first sign of blowing and stopped at the next, and in order to secure continuity of record, was immediately re-set and restarted. While, therefore, the first observation in each series represents the time from blow to blow, the succeeding observations represent the same less the time taken to read the watch which was about 2·15 sec., and the data as given in Table 3 (p. 137) have been suitably adjusted.

The data fall short of what is required in many ways. In addition to the difficulties mentioned earlier in the paper, the stop-watch was out of action for some weeks, and the following circumstances have also to be considered before the data are subjected to scrutiny. Serial observations were seldom

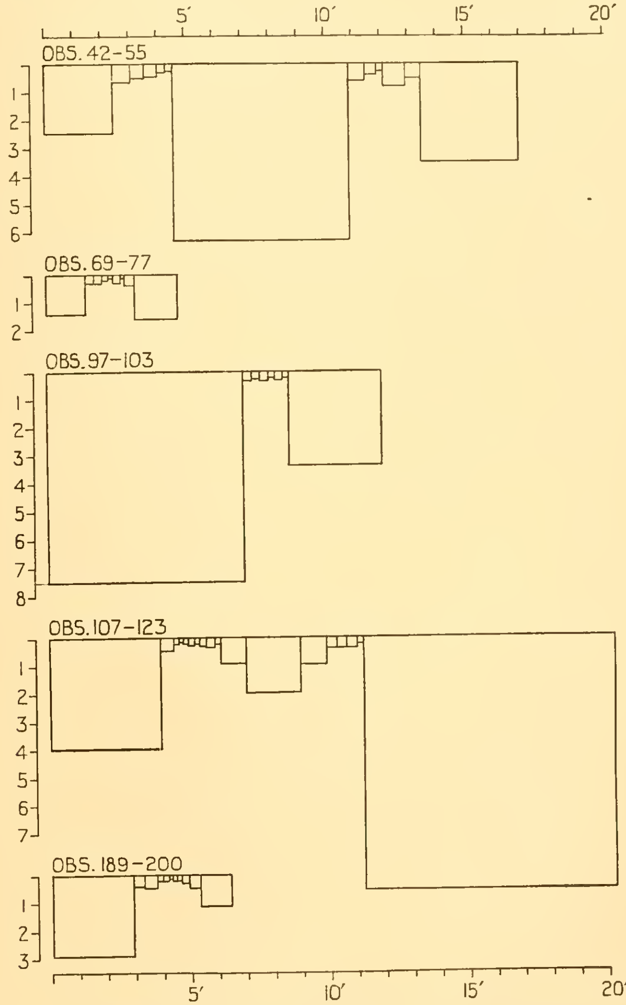

Fig. 2. Sequence of blowing and sounding intervals in minutes. The intervals are proportional to the minimum length of breath.

possible for periods longer than 20 min. A whale that might be sighted by the ship at a distance of 4–5 miles would be reached in 25–35 min., but might be disturbed considerably earlier. Evidence of such disturbance will shortly be examined. After this, observations were interrupted by marking work. Thus the observations were made as and when the marking programme permitted.

The tendency of Fin whales to swim in pairs or in schools, means that few, if any, of those appearing at a distance to be alone, are without doubt known to be unaccompanied: indeed, the data listed in

the Tables give evidence that more than one whale was under observation in each of the series of timing records made. This is most easily seen in the maximum numbers of whales blowing simultaneously, a datum which indicates with a high degree of probability the number of whales in the school.

Kemp and Bennett (1932, p. 174) have pointed out that 'If, as often happens, several whales are in company, they will generally rise to the surface and blow simultaneously. When whales are not plentiful it is possible to be reasonably certain that the same school is being kept under observation; but when they are abundant the difficulties are greatly increased.'

If the tendency to blow together could be relied upon, and the whales could be timed as a school, interpretation of these data (*A*) would be straightforward. Unfortunately, however, the appearances of the whales at the surface show a good deal of overlap and though the school often does blow together, irregularity is frequent. In view of the likelihood of confusing the blowing of one whale with that of another, the results would appear to lend themselves to almost any interpretation. But analysis shows that this is not so. The data show certain features which cannot be regarded as fortuitous: and some of these features are confirmed by the supplementary observations (B). These latter consist of isolated observations of whales close to the ship and they are important because they are believed, with a fair degree of certainty, to represent the behaviour of individual whales. The two classes of observations will therefore be considered together.

In series B, whales were commonly observed to blow at intervals of about 24–28 sec. about five or six times in succession, whereupon they sounded for a longer period. On 7 February, for example, a whale blew five times at more or less regular intervals in the course of 100 sec. and then disappeared. On 19 December, blowing went on at short intervals for 115 sec. in one instance and 140 sec. in another before the animal sounded. On occasion, when larger schools have been watched, the school has risen more often, but not every whale has come to the surface at every blowing.

Parallel instances of such rhythm in series A occur among the tabulated data and selected examples are shown in Table 1. They are illustrated in Fig. 2.

Table 1. *Comparing the lengths of the periods of sounding (I and II) with the interim period during which blowing intervals were noted*

Date	Serial no. of observation	Duration of sounding I	Interim period		Duration of sounding II	Estimated no. of whales	No. of blows observed
			Duration	No. of blowing intervals			
		min. sec.	sec.		min. sec.		
14. xii. 36	42–49	2 28	125	6	6 23	2	8
	49–55	6 23	155	6	3 27	2	7
	69–77	1 27	101	8	1 38	2	10?
22. xii. 36	97–103	7 30	100	7	3 18	2	7?
	107–117	4 27	130	10	2 52	2	10?
	117–123	2 52	132	6	9 02	2	8?
27. xii. 36	189–200	2 52	144	10	1 17	3	20?

The absence of this particular rhythm (of blowing and sounding) among others of the data listed in Table 3 may be due to the fact that some or all of the whales were behaving differently. Evidence of different rhythm is given by the whales timed on 27 December. They were first observed more than a mile off; they were approached, passed, and finally left on the starboard quarter. The observations nos. 189–200, while the whales were far off, have the rhythm illustrated in Fig. 2, but the subsequent observations, nos. 201–261, show no trace of it.

A similar though more remarkable change in the respiratory rhythm was observed (series B) in a school of six or seven whales on 3 February. At 11.15 hr. whales were sounding for long periods (4–6 min.) and between whiles were blowing a few times at short intervals in apparent unison. After many and usually fruitless attempts had been made to approach them, at 12.15 hr. they suddenly altered their behaviour in a stampede towards the south. They no longer remained below for long periods and as we slowly overhauled them, hopes of marking rose. At 13.00 hr., however, their behaviour again changed. Their complacence returned and they sounded for lengthy periods.

The rhythm demonstrated in Table 1 confirms the belief that individual behaviour may be studied in collective behaviour, for their sounding together would be unlikely if the whales' actions were unrelated. It may be helpful to compare the lengths of time the whales remained below water when sounding (interval of sounding) and the interim periods during which breaths were taken (i.e. the total of the periods occupied by successive intervals of blowing). The probability of being able to distinguish an interval of sounding from an interval of blowing is likewise important.

Two records of the latter already cited (B), were 115 and 140 sec. and they compared with sounding periods of 3 min. 8 sec., 3 min. 35 sec., 4 min. 10 sec. and 4 min. 23 sec. These figures imply that sometimes at least the sounding periods exceed the length of the interim periods.

For the purposes of comparison, an arbitrary length of time may be chosen to distinguish between the 'interval of sounding' and the 'interval of blowing'. On the basis of the data collected during the observations of 19 December, according to which the whales blew several times during the course of 140 sec., an arbitrary limit of 1 min. is liberal as an allowance for the single 'blowing interval' and any longer period of submergence may be regarded as a 'sounding interval'. When classified into intervals of less than a minute and of more than a minute, and summed, the data (A) in Table 3 give the following ratio:

$$\underset{(<1\text{ min.})}{\text{Interval of blowing}} : \underset{(>1\text{ min.})}{\text{Interval of sounding}} :: \underset{(38\%)}{64\text{ min.}} : \underset{(62\%)}{103\text{ min.}}$$

Over all the periods of observation, therefore, whales were 'sounding', according to this empirical definition, for 62 % of the time. The rhythm demonstrated in Table I suggests that, as often as not, the respiratory needs of the animals were similar; and although they did not always blow synchronously, they chose the same periods to visit the surface and the same periods to sound. It follows that a pair or school of whales may be expected to act in unison, in this sense, for at least 62 % of the time (or more if the normal 'blowing interval' is less than 1 min.). The timing data are therefore shown not to be vitiated by whales blowing out of time.

It became of interest to know whether the shorter and longer intervals were physiologically distinct or whether they are merely length variants of the same process. If the latter we might expect the longer and shorter intervals to merge and the intervals of medium length to be in the majority. The frequencies of the observed intervals are given in Table 2, showing the greatest frequency among the short intervals and a diminution with increasing length of interval. The figures suggest no obvious discontinuity between the shorter and longer breaths but that the intervals of blowing merge imperceptibly into intervals of sounding. If a distinction can be drawn between the two, the normal limit of the former is likely to be between 40 and 50 sec. A curve made up of eight-second groupings of the frequencies of the intervals of breathing is given in Fig. 3. The peak which shows at 50–54 sec. suggests that this is a frequent and well-defined interval. Intervals of 24–28 sec. were frequently found in the isolated observations (B). An interval of 18 sec. may represent a true interval of blowing, but the intervals of shorter length almost certainly do not, for the manœuvre of breaking surface alone takes 4–7 sec. The shorter intervals are probably brought about by the overlapping of the breathing intervals of different whales.

Table 2. *Frequency distribution of intervals of blowing and sounding*

Interval (sec.)	Total frequency (2 sec.)	Frequency of 4 sec. groups (i)	(ii)	(iii)	(iv)	Total	8 sec. groups frequency	2 min. groups frequency
1–2	—	—	—	—	—	—	15	
3–4	—							
5–6	11	—	6	4	5	15		
7–8	14							
9–10	25	3	29	12	6	50	81	
11–12	25							
13–14	21	3	22	3	3	31		
15–16	10							
17–18	24	8	26	6	1	41	66	
19–20	17							
21–22	18	6	13	2	4	25		
23–24	7							
25–26	13	11	10	2	4	27	33	
27–28	14							
29–30	5	4	1	—	1	6		
31–32	1							
33–34	5	3	3	—	2	8	13	
35–36	3							
37–38	2	3	1	—	1	5		
39–40	3							
41–42	—	1	—	—	—	1	2	
43–44	1							
45–46	—	1	—	—	—	1		
47–48	1							
49–50	1	3	1	—	—	4	9	
51–52	3							
53–54	3	—	3	1	1	5		
55–56	2							
57–58	1	—	1	—	—	1	1	
59–60	—							
(min.)								
0	220							227
1	7							
2	7							11
3	4							
4	2							4
5	2							
6	4							5
7	1							
8	—							1
9	1							

Note. (i) Frequency of series 1 and 3 (vide Table 3).
(ii) Frequency of series 2, 4, 5, 7, 8, 10, 13 and 15.
(iii) Frequency of series 11.
(iv) Frequency of series 6, 12, 14 and observations 78–79.

The response of whales to marking

Whales are disturbed by the sound of the ship, by the report of whale-marking guns and by the impact of the marks. At the sound of the ship they usually moved off gently, but at the report of a marking gun, or when hit with a mark they sometimes bolted to a safe distance and then slowed down.

The most timid took flight on approach of the ship: they swam off in a set direction or erratically, but keeping well out of range of the guns. A ship of 10–12 knots has no hope of overtaking these whales and they were usually abandoned by us after an hour's chase.

The less timid took flight on approach of the ship but allowed themselves to be overtaken after pursuit.

On 3 January when the whales were inclined to be on the timid side, schools of two to four allowed the ship to come within range after perhaps 10–30 min. chasing, but went out of reach immediately one of their number had been hit. On the same day a gun was accidentally discharged at a distance of 100–200 yards behind a school of 9–10 and the whales became unapproachable.

At other times a school may allow the ship at close quarters, though after every round of hitting the whales take temporary flight. Some whales grow less approachable, others more so under this treatment.

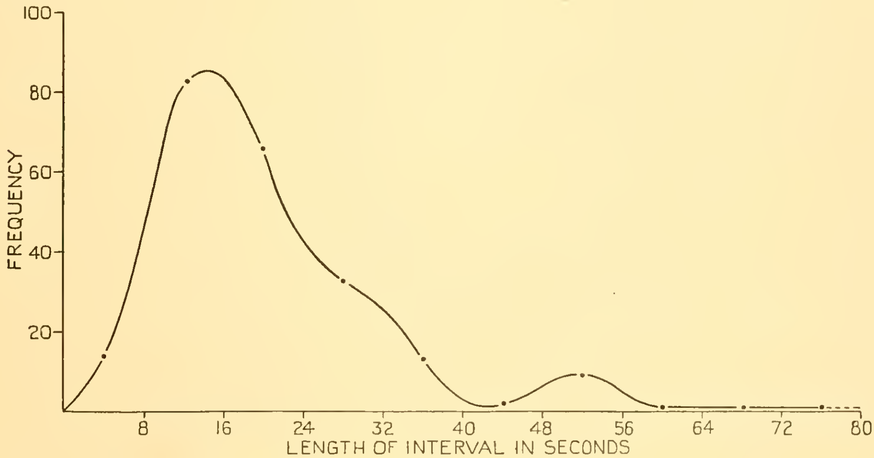

Fig. 3. Curve illustrating the frequency distribution of blowing intervals, with data lumped into 8 sec. groups.

In contrast to the occasions when whales fled from the whale-marking vessel, are the times when they took no notice of her and when they even seemed attracted. These occasions were few and as the circumstances suggest that the whales were in the act of, or had been, feeding, they will be considered later.

Another response, especially characteristic of the larger schools, is a tendency to split up into smaller groups. On 29 December, for example, a school of probably fifty split into halves. The half pursued soon split again so that no more than a dozen whales or so could be chased as a body. Later, these in turn dispersed into smaller schools of threes, fours, fives or sixes. Such splitting was frequent.

Whales very often seemed to wince on being hit by a mark: indicated by a twitching of the dorsal fin (28 December), and sometimes by a quivering of the muscles of the flank as in a horse (21 January), or by a kick with one of the tail flukes (11 January). The fluke would flick out of the water, beating about with the flourish of an irritated animal, and send up an awesome splash, sometimes wetting the ship's forecastle.

Whales not hit have also been seen to kick with a fluke at the report of a gun, though the mark that was fired was aimed at another whale and had missed it (7 February). And whales that have come towards the surface with the evident intention of blowing have, at the report of a gun, dived again.

This reaction suggests a change of mind and it has usually happened well in advance of the need to break surface; but sometimes it has happened when emergence was inevitable, as two or three times when the caudal peduncle, and once the neck region, was thrust out of the water in the act of diving (31 January and 7 February, see p. 128).

Feeding

On 11 January, whales in the act of feeding came under direct observation. A heavy concentration estimated to number 100–200 whales was centred over a patch of whale food in an area of about 4–5 square miles.

The krill (*Euphausia superba*) could be seen in a layer no more than 3 m. below the surface, and in places it affected the colour of the sea. An easterly gale the previous day had left a very heavy swell, but the wind had since moderated and waves were no longer breaking. The sky was grey and the bad visibility was reduced from time to time by patches of mist. The sea was grey too, but in places the krill imparted to it a barely noticeable tinge of ochre. In one place where the krill was unusually thick and might have been closer to the surface, a patch of half an acre or so had a brick-red tinge. The krill was irregularly spread over the whole region with large gaps between the swarms; some measured a few feet across and had an indefinite contour like that of a gorse bush, and others extended in long wavy bands from one to several feet or even metres in width. The krill did not seem as dense as patches of it often are, and it looked as though it had been broken up by the recent gale and had been depleted by the depradations of the whales.

The whales were banded together in small schools of from two to five or six or more; but the schools were probably mixing. The animals were blowing leisurely, and sounding for short periods. In the early part of the day and late in the afternoon they showed a disposition to run away from the ship; but in the middle of the morning, when they seemed to be feeding most actively, they took little heed of us and marking was comparatively easy.

The most conspicuous feature of their feeding was the tendency to swim on one side.[1] From afar, the white ventral surface shone beneath the water so that its blueness was momentarily thrown up. There would appear to be no need to look for any other explanation of this than that it is a method of turning sharply to one side (see p. 131). Whales sometimes turned out of a normal act of blowing on to their side before submerging and sometimes turned while under water; if close to the surface, flipper or fluke broke surface and waved in the air.

A point to be emphasized was the supreme indifference with which the whales accepted the marking and the presence of the marking vessel when actively feeding. They blew leisurely, sometimes swimming towards us, beneath us and by our side, and they seemed to be preoccupied with the question of their meal.

The salient facts in these observations, for purposes of future comparison, are as follows:

(i) The whales were feeding.
(ii) They were close to the surface.
(iii) They were concentrated together.
(iv) The schools were of varying size.
(v) They were blowing leisurely and at short intervals.
(vi) Their unconcern for the ship gave an appearance of preoccupation.

A rather similar state of things was observed north-west of the South Sandwich Islands on 22 January. During the morning the ship had been pursuing whales, but marking with only partial success, for the schools were unapproachable and one after another had led the ship a run of 30–40

[1] I am informed by Mr G. W. Rayner that Norwegian whalers have the word 'boltering' to describe this habit.

miles. In one of these chases at 13.00 hr. the ship came upon an area of about a square mile where ten to thirty whales were blowing leisurely. No krill was to be seen but a concourse of blackfish and dolphins crossed the area during our work. The whales were swimming close under the surface, came within a stone's throw of the ship and allowed themselves to be marked; they seemed to be crossing and recrossing the area. When the ship passed on to another region, the whales there showed the timidity of those we had seen earlier in the day.

Although no krill was visible, the presence of dolphins and blackfish presumes an abundant food supply: and though there is no direct evidence that the whales were feeding, their behaviour bore a resemblance to that of the whales met with on 11 January and contrasts with that of others in the immediate neighbourhood but outside this concentration, which were seen at almost the same time and under the same weather conditions.

The salient points may be thus tabulated:

(i) The presence of food is inferred from the concourse of the smaller as well as of the larger cetacea.
(ii) The whales were close to the surface.
(iii) The schools were of varying size.
(iv) They were blowing leisurely and at short intervals.
(v) The whales were quite unconcerned.

On 8 January around the Shag Rocks, in the middle of the day from 10.00 to 16.00 hr., the whales showed an unconcern for the ship which was in marked contrast with their usual behaviour. Chasing was begun at dawn in fine calm weather. Whales were plentiful and schools, varying in size from three or four to ten or twenty individuals, were discerned on various quarters of the horizon. Marking efforts were not unsuccessful, for as many as three or four hits in a school of six or seven were sometimes recorded before the school in question split and those whales took to prolonged flight. The whales were not sounding for more than 2–3 min. and, until disturbed, they were blowing leisurely.

Between eight and ten o'clock the attitude of the whales changed: they became scarcer and were more difficult of approach. Marking all but came to an end. The schools seemed to have scattered and apparently regardless of the operations of the ship, the whales seemed to have split up into twos and threes. They were remaining down for long periods (5–7 min.), and when they came up they were usually up to half a mile from the ship and blowing, if unhurriedly, also a trifle stertorously. The ship takes about 3 min. to steam half a mile; but however leisurely the whales were blowing—and they blew at least five or six times—3 min. was ample for their purpose. The ship was invariably on the scene too late and the whales sounded just before a shot was possible.

The whales paid no particular attention to the ship; when blowing they swam on a straight course and they did not deviate as we approached them. When they next appeared, they again had ample time to blow five times before the ship could reach them; as it did so they sounded.

In the evening, between 16.00 and 18.00 hr., whales again tended to coalesce and again allowed themselves to be pursued, and an average of one to two hits in a school of three to five whales was scored. The whales remained below for shorter periods (2–4 min.), and when on the run sounding lasted for still shorter periods (1–2 min.).

Later still, the whales had gathered into even larger schools. At 20.00 hr., a school of some twenty had been formed. They were continually breaking surface and blowing, and appeared to be disporting themselves. At first marking was easy, the whales swimming round without heed. At the sound of the guns they began to make off, but those we chased played around the ship as do dolphins; they leapt high though not completely out of the water, appeared now on the starboard bow, now on the

port; then they would streak ahead jumping high, sometimes in pairs, sometimes in threes and sometimes in unison, and then came closer to the ship again. Soon they split again, and the fewer they were the more wary they became and the harder to mark.

This one day was particularly memorable as giving us whales in three distinct moods: in early morning and late afternoon the schools of medium size which allowed pursuit and approach; before and after noon, the very small schools that were indifferent; in the late evening, the sportive whales in a large gathering. One or other of the same moods was recognized on other occasions also.

If a disposition to be preoccupied indicates that whales are feeding, as the observations on 11 and 22 January have been interpreted, then their aloof manner at noon on 8 January points to the same conclusion. Here, their behaviour had the following characteristics:

(i) The whales were widely scattered.
(ii) The schools were very small.
(iii) They were blowing leisurely at long intervals.
(iv) The whales were preoccupied.
(v) The hour was round about noon.

The most noticeable way in which behaviour on 8 January differed from that on 11 and 22 January, was the greater depth to which the whales may be inferred from (iii) to have been sounding, and the very small size of the schools. The former is thus a sign that the krill were at some considerable depth while the smallness of the school seems in some way connected.

The gathering into larger schools towards evening, the high spirits and the attention to the ship, go to indicate that the work of the day was over. We came to regard the evening as a time when whales were likely to be more markable; and in the opinion of the writer the change of attitude affords circumstantial evidence that earlier in the day, good feeding had been found at considerable depths.

Through the night, the whales may equally have been feeding or resting. What they were doing at dawn did not become apparent either. In the early morning, the schools were usually bigger and less restive, and the whales still easier to mark than later in the day.

Off South Georgia on 16 January, three whales provided, in another locality, an excellent example of the aloofness with which feeding in deep water has come to be identified. For a good hour, the ship had been hanging round the first of these whales and the prospect of marking it seemed hopeless—the animal sounded for long periods and always rose out of reach. At last at 17.10 hr. the miracle happened: the whale reappeared close to us and swam on a course which must cross our path. In many circumstances it would have turned away, but in holding its course and in diving to avoid collision it showed itself to be preoccupied, and in the light of other observations, the conclusion is irresistible that it was busy feeding.

A second example was a pair of whales met with shortly before sunset which in turn detained the ship for over an hour. When at last at 20.00 hr. by a stroke of genius, the captain manœuvred the ship into their line of advance, the whales, instead of fleeing, continued in their courses and the pair was marked in two consecutive shots (mark nos. 7006 and 7011).

Gambols and eccentricities of behaviour

Beyond suggesting that whales take part in pursuits usually termed 'play', the following note is inconclusive. That whales have shown excitement after a day's feeding has been mentioned. A gathering of them in much the same mood was met close to the surface at 13.00 hr. on 29 December. They were estimated to number about fifty and were blowing in succession with a continuity suggestive of a rocket display. The school did not seem to be feeding at the moment of our arrival, for almost

immediately it split and the whales we pursued split up again, allowing themselves to be chased late into the afternoon. Some seventeen hits only were scored. Had the animals been feeding, they would not, presumably, have allowed themselves to be chased 20 miles from the site of their food and might have been expected to show a certain indifference to the ship. The fact that they were not more approachable probably argues that they were not surfeited. Their gathering in such numbers at noon is an unexplained incident.

A similar concentration of about fifty whales was also met at 09.50 hr. on 27 December. Again, their numbers split immediately on our arrival. The visibility was not good and at 13.00 hr., after nineteen hits had been recorded, the original concentration was lost in mist.

Sometimes whales indulge in superfluous splashing when in flight. On 13 or 14 December, a school of maybe ten whales were chased at 11–12 knots. One or more of the leaders, whenever coming up to blow, slapped the surface with its head, raising sheets of spray for yards to right and left. Similar splashing has been noticed on other occasions, conspicuously in a Fin whale chased by the *William Scoresby* on 24–25 January 1931: this whale was not sounding, however, and was running away at an estimated speed of more than 12 knots.

On 21 January a single Blue whale was consorting with four to five Fin whales (mark no. 7078). The school fled, but periodically allowed the ship to overtake it and seemed to show some interest in the ship; in the course of an hour or two several were marked. The Blue whale detached itself from the school and swam within a few feet of us. It took no notice of the firing, leaping high though not clear of the water, now to the right and now to the left of the bows, and often within arm's length. The antics could not have been watched at closer quarters, but the fading light and the quickness of jumping made a detailed view of the movements impossible.

Whales have not infrequently flicked a tail fluke out of the water in the final act of diving—a mannerism very similar to but apparently distinct from the kicking movement after being hit, for it has been observed far from the ship. Certain whales were given to it more than others; some seemed prone to lift the right fluke, others the left.

Another eccentricity was shown by one whale on 22 December and by two whales on 7 January which blew without showing the dorsal fin.

Sei whales were always very difficult of approach. They took more erratic courses than Fin whales and kept well out of range; when they reappeared after sounding they were usually far away and moving in any but the direction in which the ship was heading. They were met with on few occasions.

II. MOVEMENTS BENEATH THE SURFACE

Various details in the movement of the whale as it breaks surface throw light upon the motions of the body beneath the water, though the mechanical and hydro-dynamical principles underlying these actions must at present remain undetermined.

Breaking surface

Comparison of the slow, medium and fast methods of breaking surface suggest that the three following relations are often found:

(i) The degree of curvature of the body varies inversely with the period spent above water.
(ii) The depth of body showing above water also varies inversely with the period spent above water.
(iii) The period spent above water seems to vary inversely with the swimming velocity.

From these observations it may be argued that whales without momentum have some difficulty in leaving the surface, and it may be noted that the respiratory process occupies but a small fraction of

the total period spent above water (p. 116); the rest of the time seems to be devoted to getting below again, which usually takes much longer than coming up.

A whale at the surface probably has two primary mechanical disadvantages to contend with, the surface drag and the insufficient purchase which a thin surface layer affords to the action of the flukes.

A whale at rest, or swimming slowly at the surface, in a more or less horizontal posture (Fig. 4), is probably at this disadvantage, and submergence by means of the forward motion usually observed probably means that submergence is most easily effected gradually.

The impetus acquired by whales blowing more quickly would thus appear to have a purpose in preventing a situation from arising which would be mechanically weak and would retard submergence. The movements of such whales beneath the surface appear to be as follows.

The appearance of the head and neck when the whale has broken surface, together with such a view of the body as may be gained while still beneath the water, suggests that the whale has, at first, a straightened back (Fig. 5*a*). Towards the end of the action, on the other hand, the caudal peduncle is strongly curved and the body is presumably arched (Fig. 5*g*).

The whale breaks surface with a high forward velocity which then decelerates until eventually the exposed portions at the hind-end have very little forward motion, but instead a marked vertical component.

Fig. 4. Diagrams illustrating the posture of Fin whales engaged in breaking surface and submerging leisurely.

The shape of the animal appears to the writer to be particularly suited to this act of submergence. An outstanding characteristic of the Fin whale's back anterior to the dorsal fin is its breadth, and the head especially is flattened. This is a fact that has frequently been noted, though its function appears to have been overlooked (Scammon, 1874, p. 34; Millais, 1906, p. 243). The dorsal fin itself and the caudal peduncle behind it, as remarked by Collett (1886, p. 247), Olsen (1913, p. 1076), Gray (1936, p. 199) and others, is sharply acuminate. Gray has pointed out the value of such a peduncle to the normal swimming actions of fast-swimming forms, but among rorquals it seems to have a further advantage. It will be seen that when the whale approaches the surface its action conforms most closely to the normal swimming—the body is straight and it travels forwards with high velocity—but that when leaving the surface, the body loses forward movement, arches and takes on vertical movement in a dorsoventral plane for which, in section, the fin and peduncle are well shaped.

In considering the implications of these movements, the following observations are also of assistance.

The oily looking patch left on the surface where the whale submerges, indicates that the last beat of the flukes is in an upward direction (Fig. 5*g–j*). Such action would of course be necessary to drive the whale downwards. But it follows that the penultimate beat is in a downward direction (Fig. 5*e–f*). A downward beat of the tail flukes would tend to lift the posterior part of the trunk unless the latter were able to carry out some other compensatory movement. In this connexion, the observations shown in Fig. 5*d–g* are probably significant since they show that while the body is arching, the back rises out of the water. Compare with this also the actions of the whales noted on 31 January and 7 February which dived suddenly while still beneath the surface with the hind-end of the body as they did so; one thrusting the dorsal fin and the other, both fin and peduncle out of the water (p. 124).

It would appear that the movement of the whale after it has blown, is to dip the head and the tail (Fig. 5*d*, *e*). The action of the muscles near the neck and shoulder have been noted, and at this time the whale is still travelling forwards. The arching of the body in the region of the dorsal fin shows that

the tail is also being flexed, and its rising out of the water, as noted in the figures, may be regarded as a consequence. The resulting posture probably resembles that shown in Fig. 5*g*, and the whale would appear to have gained a position of mechanical advantage: almost as much is hinted by Racovitza (1903, p. 36). In this position, the flukes are sufficiently buried to have purchase for the final dive, while the flattened head and the broad shoulders reaching downwards afford a bearing against which force can be transmitted.

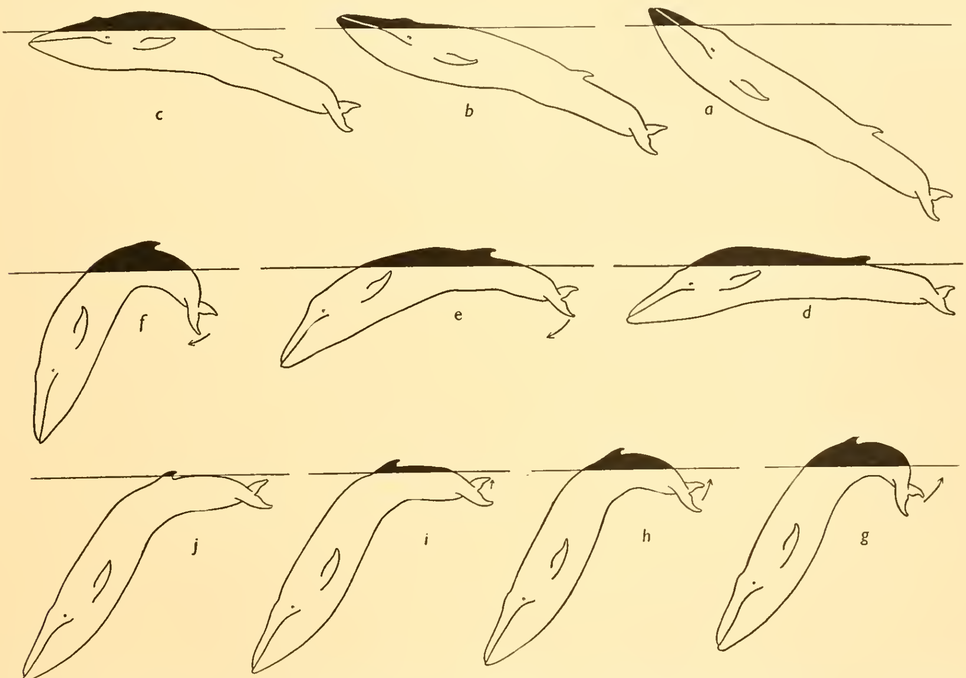

Fig. 5. Diagrams illustrating the posture of Fin whales in ten stages while breaking surface and submerging at medium speed. The arrows in *e–i* indicate the supposed direction of the beat of the tail flukes.

The head, dorsal fin and caudal peduncle

The head in rorquals may thus function as a vane and may perhaps be compared to the outstretched hands of a diver or to the elevators of a submarine. In the vertical plane its effects would thus appear analogous with those shown by Gray (1933, pp. 115–24) to result from lateral turning of the head in fish.

Authors have usually found difficulty in ascribing an appropriate function to the Balaenopterid dorsal fin, and Howell (1930, p. 59), while suggesting its possible use as an equilibrator, also points out the difficulty of accepting this conclusion about an animal swimming by a vertical motion of the tail.

The fact observed above that the fin is usually the last part of the body to sink beneath the surface and that it makes no splash, suggests strongly that it is streamlined for the purpose and that it facilitates submergence. Closer examination shows that the leading edge of the fin is normally set at an angle of about 150° to the back anterior to it, but the angle is greatly increased when the back is arched so that the edge of the fin tends to come into line with the curve of the back. The broad lines of the

back in the bent position thus taper until the tip—not of the tail—but of the fin is reached, and as they submerge together, the whole sinks obliquely forwards with remarkably little disturbance to the water.

The caudal peduncle should be considered together with the dorsal fin because it seems to share the same function and has similarity of shape. Its structure has been frequently misrepresented (Scammon, 1874, p. 37 and plate 11, fig. 2; True, 1904, plate 48, fig. 1; Millais, 1906, plate 59, figs. 2, 3; Lillie, 1915, plate VII, fig. 1; Allen, 1916, plate 10, etc.).

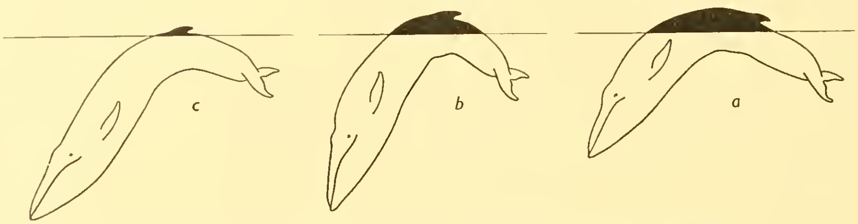

Fig. 6. Diagrams illustrating the posture of Fin whales swimming at high speed.

The point in need of particular emphasis, is the insertion of the flukes on the peduncle. The majority of authors have shown the plane of the flukes to lie more or less midway between the dorsal and ventral contours of the peduncle, whereas in fact it is very distinctly nearer the ventral edge. In Fig. 7*a*, which is based on photographs published by True (1904, plate 11, fig. 4 and plate 14, figs. 1, 2), two-thirds of the peduncle are shown dorsal to the plane of the flukes and in southern Blue and Fin whales it is approximately the same (Plate XXXIII, fig. 6; Fig. 7*b*). Collett (1886, plate XXV, fig. 1) and Olsen (1913, plate CXI, fig. 7) have respectively shown the same thing for the Sei whale and Bryde's whale.

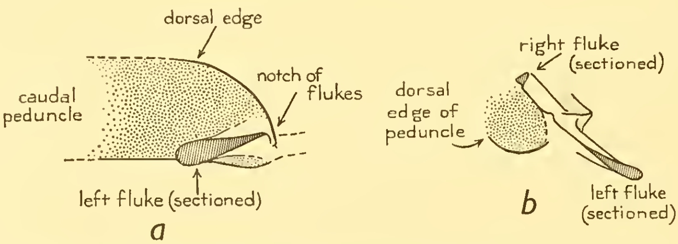

Fig. 7. Diagrams of the caudal peduncle. *a*, viewed from the left side (*Balaenoptera musculus*, from True, 1904). *b*, viewed from behind and from the right side, as in Plate XXXIII, fig. 6 (*B. physalus*).

When whales dive at unusually steep angles they submerge the fin before the peduncle and the streamline form of the latter in transverse section is then seen to best advantage. By its great depth—4 ft. in a 65 ft. whale (Howell, 1930, p. 204)—the flukes are kept well beneath the surface as long as possible.

In considering the effects of the flattened head and its mobility, the streamlined dorsal fin and the caudal peduncle, it would be interesting to know more about the habits of other whales. The Right whale is also a plankton feeder and visits the surface to breathe but is said to be slow in its movements. In this whale the maxillae are laterally narrow and dorsoventrally curved; mobility of the head is reduced by extensive fusion of the cervical vertebrae and it has no dorsal fin. Killer whales and dolphins which feed upon active prey have very much larger dorsal fins placed farther forward. The

possible advantage of this to an organism in need of turning sharply to right and left is suggested by the results obtained by Harris (1936) on the dorsal fins of fish, and it seems probable that the fins of rorquals are in no way analogous to the fins of these other cetaceans.

As compared to the ease with which rorquals are able to turn sharply upwards or downwards, their movement from side to side appears to be restricted. This is suggested both by the structural arrangement of the fins, flukes and flippers, and also by the behaviour of Fin whales when feeding. Their habit of turning on to their sides when moving about among small patches of food has often been recorded (Millais, 1906, p. 255), and Andrews (1909, plate XL, fig. 1) has photographed a whale in this position. This seems most probably to be a turning movement. The very localized and irregular distribution of the krill must demand a twisting motion which is probably beyond these whales in their normal swimming position. The flattened head and laterally extended flukes, while they are evidently well adapted for the purposes of turning upwards or downwards to and from the surface, seem incapable of giving an equally sharp turn to right or left: like an aeroplane it has to bank.

III. COMPARISON WITH EARLIER ACCOUNTS

True (1903) and Allen (1904) give brief descriptions of Finbacks off Newfoundland which agree well with the type of movement described on pp. 116, 117. True, however, reports having seen little or nothing of the back behind the dorsal fin, although the whales are described as having come up to the surface obliquely and as exhibiting strong curvature (p. 92). On some points, however, True's photographs differ from the text. In his plate XXV, fig. 1, a relatively short length of back shows above water as its curvature and the position of the head clearly indicate. The fin is still well submerged; yet True states that 'The whole upper surface of the body from about the middle of the head to the dorsal fin is above water...'. The text suggests that in fig. 2 the dorsal fin is hidden by a wave, but the position of the whale shows clearly that the fin itself is outside the picture and is probably still below water.

Both True and Allen note the lowering of the head and the arching back, but neither draws attention to the fact that the back rises out of the water, nor that the wheeling motion slows down. Millais (1906, p. 268), however, states 'The Finback simply lifts itself a little higher and goes down smoothly and silently and goes down at an oblique angle', and Andrews (1909, p. 216) makes a similar remark.

Racovitza (1903) distinguishes between two types of action at the surface, the one concerned with the longer and deeper dive which he terms 'La Sonde' and the other with 'Les plongements intermédiaires'. According to Racovitza, inspiration and expiration are deeper before and after sounding than before the intermediate dive, but comparative data are not given. Again, the intermediate dives last a few minutes, whereas sounding seldom lasts less than a quarter of an hour, but more precise data are not given. The whales are also said to dive more shallowly intermediately than when sounding, though how the depth of the whale was judged during the minutes it was out of sight is not made clear. And lastly, the curvature of the back is held to be greater before sounding than before the intermediate dive. Racovitza ascribes a regularity to these movements which the present writer finds impossible to accept; they will be considered in further detail.

His first point (p. 6) that 'L'expiration se produit exactement au moment où le sommet de la tête,...arrive à la surface' does not reckon with the habit Fin whales sometimes have of blowing off air while the blowhole is still submerged (see p. 117), which appears also to have been noted by Howell (1930, p. 91). And his claim that 'C'est la bosse de l'évent qui signale l'animal' can be accepted only for those whales which approach the surface in a more or less horizontal position. Such whales appear to have been observed by Allen (1904, p. 615).

Racovitza has allowed 5–6 sec. for the duration of the blowing, which is greatly in excess of our

estimate. According to direct observations made during the course of the present work, little more than 1 sec. elapsed from the first appearance of the head above water to the submergence of the blow-hole. This is astonishingly short and is rather shorter than an estimate of the time made by indirect methods, according to which the blowing might perhaps take 3 sec., but even this is half the time allowed by Racovitza.

We are agreed with the view that the time taken over inspiration is shorter than the time taken over expiration which immediately precedes it. Racovitza, however, maintains (p. 12) that 'La bosse de l'évent est toujours la seule partie qui apparaît à ce moment sur l'eau', whereas numerous photographs of living whales have shown other parts of the head and neck also above water. On p. 13 he notices the neck bend, but for the intermediate dives he states that 'chez les Balénoptères la dorsale ne se montre pas'. In the present series of observations, the dorsal fin showed above water after almost every act of blowing seen (see p. 127).

Whether it is possible to infer from the attitude of a whale whether it is making an intermediate dive or whether it is sounding, may be questioned, as indeed may so many of Racovitza's assertions. Andrews (1909), whose ideas are evidently modelled to a considerable extent upon Racovitza and Millais, touches upon the subject but gives little that can be looked upon as corroborative evidence. The posture of a whale diving at a steep angle is admittedly different from that of a whale swimming horizontally, but whales have frequently been seen by the writer to dive at a steep angle during intermediate dives.

The view expressed by Andrews (1909) and Allen (1916) that the 'slick' left by the whales is due to the counter-currents produced by the displaced water as the whale comes to the surface and withdraws; or that it is 'incontestablement une couche de graisse extrèmement mince, qui s'étent à la surface de l'eau et qui lui donne cet aspect bien connu du miroir' (Racovitza, 1903, p. 15); or yet again, the theories elaborated earlier leave out of account the fact that the patches often appear in series when the whale does not break surface. They seem far more likely therefore to represent a gush of water propelled upwards by the tail flukes.

Respiratory rhythm

Racovitza's estimate of the time taken over an intermediate dive 'plus ou moins longtemps, mais sans jamais dépasser un petit nombre de minutes' (p. 13), like his estimate of sounding 'rarement inférieure à un quart d'heure' (p. 14) are far longer than our own.

Owing to their limited number, our observations by no means exclude the probability that whales can and do remain below for very much longer periods than we have been able to show. The estimates of 15 min. made by Millais (loc. cit. p. 268) and of 23 min. by Andrews (1909, p. 225) are by no means unreasonable and are to be expected from our data. But periods of over a quarter of an hour are certain to be exceptional as compared to the frequency of sounding for shorter periods.

In this our results confirm the observations of Allen (1904, p. 615) 'They rose to spout about once in every 12 to 15 seconds with great regularity for perhaps twelve times, after which they dove for a much longer stay of several minutes. The precise length of the longer periods was not accurately determined, but could hardly have been more than five or ten minutes.'

The mean of seven instances of such rhythm given in Table 1 shows the schools to have been blowing at 16 sec. intervals seven to eight times and then to have been sounding for about 4 min. Individual whales were blowing less often, however; the figures gave an average of four to five times at intervals of 26–27 sec. between each sounding. When feeding at the surface, or in flight, whales did not show this rhythm and sounded less, so that the respiratory rhythm reflected to some extent their occupation. Andrews (1909, p. 224) also has observed 'that Finbacks, when feeding, often rise to respire with

considerable regularity, but in general the time the animals will remain submerged is most uncertain'. Whether this has any connexion with the depth of the food is not known and it was unfortunately impracticable on the *Skua* to tow nets with the object of locating it.

Feeding

Dudley (1725, p. 262) has made a suggestion that has often been copied by later writers (Buchet, 1895; Racovitza, 1903) that Fin whales 'with a short turn, cause an Eddy or Whirlpool by the Force of which, the small Fish are brought together into a Cluster; so that the whale with open Mouth, will take in some Hundreds of them at a Time'. The practice has not been seen by the writer.

The swarming habit of *Euphausia superba*, the staple of whale food around South Georgia, is a characteristic to which Hardy & Gunther (1935) have already drawn attention. Patches of krill at the surface of the sea, similar to, but more pronounced than, those noted on p. 124 have been observed by the writer in areas marked by a conspicuous absence of whales, which need not be instrumental, therefore, in bringing the swarms about. The belief would seem to have arisen as a fisherman's explanation of the swarming and its frequent association with 'boltering' whales (see p. 131).

Millais (1906, p. 255), who also passes the story on, states 'After one or two subsidiary circles to drive their prey together, they give a sudden start forward, at the same time turning on their side and erecting the pectoral fin'. Erection of the flipper has been noted on p. 124 and is also figured by Andrews (1909, plate XL, fig. 1). It would seem likely to help the whale both to turn on to its side and to lessen the radius of its track.

Gambols

Compared to the Humpback, Fin whales are described as seldom indulging in gambols or other antics, though movements that are not habitual are sometimes noted. Scammon (1874, p. 35) writes: 'It frequently gambols about vessels at sea, in mid-ocean as well as close in with the coast, darting under them, or shooting swiftly through the water on either side; at one moment upon the surface, belching forth its quick ringing spout, and the next instant submerging itself beneath the waves, as if enjoying a spirited race with the ship dashing along under a press of sail.' But this author is alone in noting that the Fin whale sometimes heaves its flukes out. The present writer is able to confirm an observation made by Allen (1916, p. 194) that one or other but never both flukes leave the surface.

Millais (1906, p. 218) has referred to an observation that when a party of Killers were attacking a Common Rorqual, the main herd of whales about a mile to windward, began lashing about on the surface to give the alarm, and were seen then to make off at great speed in all directions. Later (p. 268) he states that the flukes never leave the surface, so that the lashing might have been with the head or flipper.

Allen (1916, p. 194) states that 'The Finback whale seems but rarely to leap out of water'. One is reported to have done so after it had sustained injury upon some rocks, and he quotes another instance of breeching reported by Prof. W. Kukenthal.

Breeding habits

The available descriptions of courting and of other breeding habits admit of the possibility of a variety of methods by which union of bull and cow or cow and calf might be effected, but all writers, so far as is known, have omitted to stress the principles underlying the manner of approach of the partners to one another (Dudley, 1725, p. 260; Haldane, 1906, p. 133; Southwell 1906, p. 195; and others).

As bodies floating in the water and unpossessed of prehensile limbs, they lack the purchase on terra firma by means of which animals on dry land are able to make physical contact. This disability would

seem most easily overcome when whales have steerage way, and in fact, pilots know well the nice adjustments of which craft are capable provided they have sufficient way on. Animals so well adapted to the water as whales, which swim for almost every breath, might reasonably be expected to swim for their other essential functions; and the suggestion by Anderson (1746), Pontopiddan (1752), Brown (1868) and Millais (in respect of the dolphin, 1906, p. 220) that cetacea adopt a vertical position, or by Lillie (1910, p. 791) that they make several dashes at one another, seem unlikely both on account of lack of good evidence and on account of the principles noted above.

Whales with calves were observed on various dates but never seen to suckle. Whether the calf takes the teat between the extremity of the jaws (Scammon, 1874, p. 45) or whether in the corner of the mouth (Haldane, 1906, p. 133) remains an open question, and the way in which the apparently rigid lips are able to take milk to the exclusion of salt water is also an undecided question.

Whales with calves were usually timid. They were noted on 12 and 23 December, 7, 12, 30 January and 7 February. On 22 January a whale with a very young calf showed an unusual unconcern for the ship and swam close to her; this was an occasion when the whales were judged to be feeding (p. 124). The whale of 7 February was attended by two calves and was brought within range. The mother (?) and one calf were marked (nos. 7348 and 7370 (cow) and 7369 (calf)), but though the family were chased for an hour and a half the second calf got away unmarked. Their rates of blowing for a period of 8 min. are noted in Table 4.

Intercommunication between whales

The behaviour of the school leaves no doubt that intercommunication is remarkably efficient, but as to the means nothing is definitely known. The precision with which four and five whales will blow together, and the way in which schools half a mile or so apart readily join up, or when scattered over a very much wider area, coalesce, are instances that may be witnessed every day. The senses of sight, smell, taste and hearing may each have their part.

Whales in close formation are doubtless able to see each other, for in deep water and at night they probably leave a trail of luminescence behind them, induced in the planktonic organisms. Such luminescence is known to be produced by dolphins but as an effective recognition signal it can hold for only short distances.

Little is known about the whale's olfactory sense. As regards airborne smell, it is of interest that a whale's breath may be detected at a distance of at least 200 yards to windward, but this may be excluded for purposes of communication because scent is not usually detected on the surface of water. Waterborne smell is a possibility that might affect the whale through some such organ as Jacobsen's organ, or through taste.

The problem of locating food has application here, for if a sense of smell or the taste buds of the tongue subserve this purpose, they may also enable the whales to trace one another. On the other hand, the presence of food may be detected physically by means of the bristles of the head which have been shown to be highly innervated.

The hearing of whales is remarkably sensitive. The report of a small charge of gunpowder in open ocean against wind and at a distance of several yards, has put whales beneath water to flight (see also p. 122). Norwegian whalers believe that whales hear the shout of a man in the crow's nest. A sensitive ear or equivalent sense in the bones of the head, implies use and raises the question of what sounds may be produced by whales.

Their blowing on a calm day can be heard half a mile away, but we do not know whether the noise is transmitted to water. On two occasions the low vibrant quality of the note was accompanied by a higher. An observer on board ship can never be sure that an unusual note coinciding with a whale's

appearance has not had its origin on board. Apart from these, and in spite of the close attention that has been paid to the subject during this commission, no other noises have been identified with the whales.

Asymmetrical pigmentation of Fin whales

An account of the pigment distribution in Fin whales has been given by Mackintosh and Wheeler (1929), and attention is directed to the asymmetrical arrangement of pigment on the jaws (p. 354). The report also makes an interesting speculation on the possibility that Fin whales might swim slightly on their right side while under the water.

The suggestion is based, presumably, on the analogy of Thayer's ducks, according to which the shadowed and the highly lit aspects of an animal are differently pigmented; or alternatively there is the theory that the more exposed portions of the whale may be pigmented as a protection against the action of the sun's rays. In either case a regular turning on to the right side might reasonably be expected.

Of the many whales watched, a vast majority broke surface and sounded on an even keel. Moreover, of the whales which turned on to their sides when 'boltering' or when raising a single fluke above the surface, some were on their right side, others on their left. As far as they go, the observations give no evidence of habitual twisting in the water and the asymmetrical distribution of pigment remains a problem.

SUMMARY AND CONCLUSIONS

1. The habits, swimming manœuvres, bodily movements, respiratory rhythm and reactions of fin whales have been noted during a programme of whale marking operations near South Georgia. The observations were made between Dec. 10th and Feb. 9th, 1936–7. At this season the whales are known to be feeding.

2. An observed reaction to the presence of the ship has been an alteration in the respiratory rhythm, but other changes of behaviour are likely. Difficulties of observing whales at a distance are pointed out and the view obtainable from the decks of a catcher might give rise to a wholly erroneous picture of the ways of the unmolested animal. With these reservations the following deductions have been made.

3. The way the whale breaks surface to breathe and submerges again is analysed into its component movements. In the process of submergence the body may travel forwards with the body extended, or downwards with the body doubled. The latter was the most usual and the structure of head, dorsal fin, peduncle and flukes are shown to be particularly adapted for this action. Breathing requirements impose a need to overcome mechanical difficulties not met with by fish. Quick visits to the surface would seem to involve certain mechanical difficulties which these adaptations are designed to overcome: and this specialization for dorsi-ventral turning has resulted in the peculiar habit of feeding on the side.

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APPENDIX

Table 3. *List of blowing intervals timed by stop-watch*

Series no.	Serial no. of observation	Date	Corrected interval	No. of blows observed	Notes
			min. sec.		
1	1	12. xii. 36	25		Two whales
	2		27		
	3		27		
	4		25		
	5		52		
	6		32	1	
	7		29	1	
	8		2 27	1	
	9		48	½	
	10		2 02		
	11		51		
	12		5 02	1	
	13		26	1	
	14		19	1	
	15		18	1	
	16		?	1	
	17		20	1	
	18		27	1	
	19		35	1	
	20		?		
	21		22	1	
	22		4 29		
	23		40	1	
	24		22	1	
	25		17		
	26		—		
	27		28	1	
	28		28	1	
	29		16	1	
	30		23	1	
	31		10	1	
	32		44	1	
	33		17	1	
	34		13	1	
	35		30	1	
2	36	14. xii. 36	55	2	
	37		5 32	1	
	38		17	2	
	39		19	1	
	40		6 02		
	41		6 02		Abandoned chase of disappearing whale
3	42	14. xii. 36	39	1	
	43		2 28	1	
	44		38	1	
	45		30	1	
	46		27	2	
	47		17	1	
	48		13	2	
	49		6? 23	1	
	50		33	2	
	51		25	1	
	52		11	1	
	53		52		
	54		34		
	55		3 27		
	56		19		
	57		2 15	1	

Table 3 (*cont.*)

Series no.	Serial no. of observation	Date	Corrected interval min.	Corrected interval sec.	No. of blows observed	Notes
	58			22		
	59			18	1	
	60			25	1	
	61			22	1	
	62			09		
	63		?	22	2	
4	65[1]	14. xii. 36		35	1	> 1 whale
	66			22	1	
	67		1	19	1	
	68			20	1	
	69		1	27	1	
	70			17	2	
	71			17		
	72			13		
	73			7		
	74			19		
	75			7		
	76			21	2	
	77		1	38	1	Remainder disappeared
	78	14. xii. 36		7		after marking
	79			22		? joined group ½ mile off
5	80	15. xii. 36		12	1	
	81			14	1	
	82			12	2	
	83			16	1	
	84			12	2	
					1	
6	85	18. xii. 36		15	1	Two whales approached
	86			27		slowly and fled in calm
	87		3	47		weather, light breeze, sun and mist
7	95	22. xii. 36	7	30		Loitering ¼ mile distant
	96			?		
	97			22		
	98			16		
	99			19		
	100			12	2	
	101			19		
	102			12		
	103		3	18		
	104			24		
8	105			12		
	106			50		
	107		4	27		
	108			28		
	109			14		
	110			8		
	111			9		
	112			14		
	113			10		
	114			14		
	115			19		
	116		2	14		
	117			52		
	118			54		
	119			22		
	120			22	2	
	121			21	2	
	122			13		
	123		9	2		

[1] No. 64 omitted in M.S.—*Ed.*

Table 3 (*cont.*)

Series no.	Serial no. of observation	Date	Corrected interval	No. of blows observed	Notes
			min. sec.		
	124		57		
10	185	27. xii. 36	15	3	3 Fin, 1 mile
	186		15	3	
	187		17	1	
	188		17	1	
	189		2 52	1	
	190		25	3	
	191		27	3	
	192		11	1	
	193		13	2	
	194		8	1	
	195		9	2	
	196		11	1	
	197		13	2 (or 3)	
	198		27	2	
	199		?		? 1 interim blow
	200		1 7	1	
	201		19	3 or 2	
	202		26	3	
	203		14	2	
	204		15	1	
	205		10	2 ?3	
	206		19	1	
	207		26	2	
	208		34	1	
	209		17	3	
	210		19	3	
	211		15	1	
	212		11	3	
	213		17	2	
	214		21	3	$\frac{1}{4}$–$\frac{1}{2}$ mile
	215		22	2	
	216		26	2	
	217		34	3	
	218		9	1	
	219		21	1	
	220		12	1	
	221		12	2	
	222		18	2	
	223		18	2	
	224		11	1	
	225		12	2	
	226		14	2	
	227		19	2	
	228		9	1	
	229		7	1	
	230		11	2	
	231		15	1	
11	232		13		4 min. after last record: 3 whales swimming parallel to ship and left on starboard quarter
	233		9		
	234		19	3	
	235		25	3	
	236		8	1	
	237		8	1	
	238		13	2	
	239		17	1	$\frac{3}{4}$ mile
	240		22	? 1	
	241		25	3	
	242		9	1	
	243		17	1	

Table 3 (*cont.*)

Series no.	Serial no. of observation	Date	Corrected interval	No. of blows observed	Notes
			min. sec.		
	244		9	1	
	245		14	2	
	246		19	2	
	247		9	1	
	248		6	2	
	249		9	?3	
	250		12	2	1 mile
11	251	27. xii. 36	12	2	
	252		9	1	
	253		7	1	
	254		17	1	
	255		10	2	
	256		24	1	
	257		9	2	
	258		54	1	
	259		10	1	
	260		12	2	
	261		18	1	
12	262		7		2 miles
	263		35		
	264		37		
	265		30		
	266		1 37		
	267		3 17		
	268		9		
	269		11		
	270		11		4 whales
13	271		6 6	1	?2 miles
	272		27	2	?½ mile
	273		17	1	
	274		17	2	
	275		12	1	
	276		8	1	
	277		11	3	
	278		11	1	
	279		13	1	
	280		9	2	
	281		55	1	¼ mile
	282		10	1	
	283		14	1	
	284		39	1	
14	285		9	1	Ship receding
	286		54	1	
	287		11	2	
	288		9	1	
	289		22	1	
	290		8	1	
	291		7	2	
	292		26	1	
	293		7	1	
	294		14		
	295		2 50		
	296		28		
	297		23		
	298		22		
	299		26		
	300		18		
	301		34		?1 min. 34 sec.
	302		13		?2 miles off

Table 4. *Timing observations of an adult and two calves*

Series no.	Serial no. of observation	Date	Corrected interval	Observed appearances		Supposed appearances	
				Adult	Calves (nos.)	Calf	Calf
			min. sec.	min. sec.	min. sec.	min. sec.	min. sec.
15	303	7. ii. 37	00				
	304		29		29 (1)		
	305		10	39			
	306		18		28 (1)	?	57
	307		19	37			
	308		19		38 (1)	1 6	1 6
	309		28	?47	?28 (1)		
	310		23	23			
	311		28	28			
	312		18	18	1 9 (1)	1 37	
	313		24	24	24 (2)	24	1 33
	314		23	23	23 (1)	23	
	315		12		12 (1)		35
	316		9		9 (1)	21	
	317		15		15 (1)		24
	318		1 42	2 18	1 42 (2)	1 57	1 42
	319		18	18			
	320		9		27 (1)	27	
	321		14	23			
	322		1 42		1 56 (2)	1 56	2 23

PLATE XXXIII

Fig. 1. Fin whale blowing leisurely, with blowhole, dorsal fin, and dorsal edge of the caudal peduncle visible above the surface. The appearance of the peduncle suggests that the body is exceptionally horizontal. (See Fig. 1 *b* in the text.)

Fig. 2. Fin whale blowing fairly leisurely, with blowhole and dorsal fin both visible. The 'spout' is just visible above the back, and the head has moved forward (to the right) during inspiration. (See Fig. 1 *b* in the text.)

Fig. 3. Fin whale blowing at medium speed. The whale is moving away from the observer, and the open blowhole can be seen. (See Fig. 1 *f* in the text.)

Fig. 4. Fin whale blowing at medium speed. The back is flexed and the blowhole now submerged. (See Fig. 1 *g* in the text.)

Fig. 5. Fin whale blowing at high speed. (See Fig. 1 *n* in the text.)

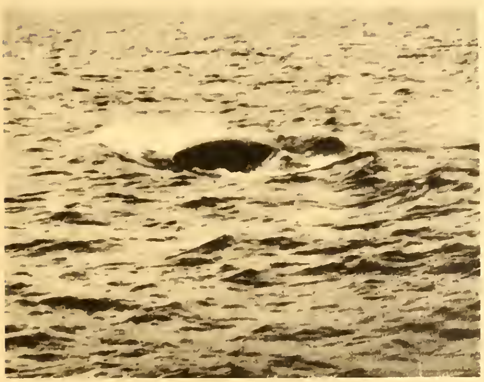
Fig. 6. View of Fin whale from the rear, to show height of dorsal edge of caudal peduncle. The whale is lying on its left side. The plane of the flukes is more nearly in line with the ventral than with the dorsal edge of the peduncle. The outer parts of the flukes have been cut off. (See Fig. 7 *b* in the text.)

1

2

3

4



5

6

FIN WHALES

[*Discovery Reports. Vol. XXV, pp.* 143–280, *Plates XXXIV–XXXVII, September*, 1949]

DISCOVERY INVESTIGATIONS STATION LIST

R.R.S. 'WILLIAM SCORESBY'

1931–1938

CONTENTS

DISCOVERY INVESTIGATIONS
STATION LIST
R.R.S. 'WILLIAM SCORESBY'
1931–1938
(Plates XXXIV–XXXVII)

INTRODUCTION

Particulars of the earlier observations made by the R.R.S. 'William Scoresby' up to St. WS 575 (26 March 1931) were included in the Station Lists already published in vols. I, III and IV of the *Discovery Reports*. Subsequent lists contained only particulars of observations made by the R.R.S. 'Discovery II' between October 1931 and May 1939 (*Discovery Reports*, vols. XXI, XXII and XXIV). The present list gives particulars of the observations made by the 'William Scoresby' between April 1931 and February 1938.

In the early part of this period (from April to September 1931) the 'William Scoresby' carried out an oceanographical survey of the Peru Coastal Current, during which many stations (WS 576–748) were (with a few exceptions) worked off the coasts of Chile and Peru. This work on the Peru Current was followed by a trawling survey of the Patagonian Continental Shelf (Sts. WS 749–882, from September 1931 to April 1932)—the third trawling survey carried out by the 'William Scoresby' in these waters. Particulars of the earlier surveys have already been given in the Station Lists published in vols. I and III.

From 1934 to 1938 the 'William Scoresby' was engaged in marking whales in the Antarctic. Four commissions, each of approximately seven months, enabled the ship to spend about four months on the pelagic whaling grounds each season. Opportunities for oceanographical work were few, but a certain number of hydrological observations, to a depth of 400 m., were made during the first three commissions. A limited number of biological observations, mainly with towed nets, were also made throughout all the whale-marking commissions. These biological and hydrological observations were recorded under station numbers in the usual way.

In the 'William Scoresby' lack of adequate facilities normally prevents chemical analysis of water samples on board. It would be impossible at any time to carry out the full series of analyses which are part of the normal routine in the 'Discovery II', but, for the period of the Peru Coastal Current Survey, temporary arrangements were made so that estimations of phosphate and dissolved oxygen could be carried out on board. These arrangements were not, however, wholly satisfactory and the results obtained should be used with caution. It is probable, though, that in most cases the errors are slight. On the other hand, samples taken for the determination of salinity can be kept almost indefinitely and those taken during the Peru Survey were therefore stored on board and titrated in a shore laboratory at a later date. The accuracy of the figures for salinity conforms, therefore, to our normal standard.

The abbreviations which denote the nature of the bottom are those now used by the Hydrographic Department of the Admiralty.[1] Of these the following appear in this station list:

b	blue	f	fine	M	mud	Sh	shells
bl	black	G	gravel	Oz	ooze	sk	specks, speckled
br	brown	gn	green	P	pebbles	Sn	shingle
c	coarse	gy	grey	R	rock	St	stones
Cy	clay	h	hard	S	sand	v	volcanic
d	dark	lt	light				

∸ placed above the figure for the sounding indicates that bottom was not reached.

An asterisk following the figure for the sounding indicates that the depth was obtained by echo sounding.

[1] See Chart No. 5011, *Explanation of signs and abbreviations as shown on the charts issued by the Hydrographic Department, Admiralty*. Hydrographic Department, Admiralty, 1946.

In conformity with our later practice (see Station Lists, vols. XXI, XXII and XXIV) the force of the wind is given as the velocity in knots. The state of the sea is expressed as a number in the Douglas Sea Scale, which is as follows:

STATE OF SEA

Scale number	Description
0	Calm
1	Smooth
2	Slight
3	Moderate
4	Rough
5	Very rough
6	High
7	Very high
8	Precipitous
9	Confused

The following symbols are used to denote the state of the weather:

b	blue sky whether with clear or hazy atmosphere, or sky not more than one-quarter clouded.
bc	sky between one-quarter and three-quarters clouded.
c	mainly cloudy (not less than three-quarters covered).
d	drizzle or fine rain.
e	wet air without rain falling.
f	fog.
fe	wet fog.
h	hail.
m	mist.
o	overcast sky (i.e. the whole sky covered with unbroken cloud).
p	passing showers.
q	squalls.
r	rain.
rs	sleet (i.e. rain and snow together).
s	snow.
v	unusual visibility.

Time is expressed in the 24-hour system ending with midnight (0000). The difference of ship's time from Greenwich mean time (GMT) is noted in the 'Remarks' column, this difference holding good until another entry is made. Times in heavy type refer to biological observations made between sunset and sunrise.

The following symbols are used for nets, apparatus, etc.:

B	Oblique.
BNR	Russell's bottom tow-net. A 1 m. stramin net (N 100) on a rectangular frame attached to skids which raise it clear of the bottom.
BTS	Small beam trawl. Beam 8 ft. (2·45 m.) in length: mesh at cod-end ½ in. (1·25 cm.).
DC	Conical dredge. Mouth 16 in. (40·5 cm.) in diameter, with canvas bag.
H	Horizontal.
KT	Kelvin sounding tube.
LB	Leather bucket.
LH	Hand lines.
N 4–T, N 7–T	Nets of 4 mm. (0·16 in.) or 7 mm. (0·28 in.) mesh attached to the back of trawl.
NCS–T	Tow-net of coarse silk (16 meshes to the linear inch) attached to back of trawl.
N–T	Net (mesh not specified) attached to back of trawl.
N 50	50 cm. silk tow-net. Mouth circular, 50 cm. (19·5 in.) diameter: 200 meshes to the linear inch.
N 70	70 cm. tow-net. Mouth circular, 70 cm. (27·5 in.) diameter: mesh graded, at cod-end of silk with 74 meshes to the linear inch.

N 100	1 m. tow-net. Mouth circular, 1 m. (3·3 ft.) diameter: mesh graded, at cod-end of stramin, with 10–12 meshes to the linear inch.
NH	Hand net.
NHP	A modification of Harvey's phytoplankton net.[1] The apparatus measures the volume of water filtered through a small sleeve-shaped silk net of 200 meshes to the linear inch.
OTC	Commercial otter trawl. Head rope 80 ft. (24·5 m.) long: mesh at cod-end $1\frac{1}{2}$ in. (3·8 cm.).
TYF	Young fish trawl. A bag of stramin, with 10–12 meshes to the linear inch, attached to a circular frame 2 m. (6·6 ft.) in diameter. With bucket at cod-end.
V	Vertical.

To the symbols for tow-nets (N 100, N 70, N 50 and TYF) B, H or V is always added to indicate whether the haul was made obliquely, horizontally or vertically. For determining the depths of horizontal and oblique nets, Kelvin sounding tubes were used. Their use is indicated by the appropriate symbol in the 'Remarks' column; where the tube failed to register the depth was estimated and is noted as such. When the depth of termination of an oblique haul is written (–0) it should be understood that the net failed to close at some intended intermediate depth and fished all the way to the surface.

At the end of the list (p. 280) will be found a Summary of the Stations made by the R.R.S. 'William Scoresby' from April 1931 to February 1938, with references to the charts (Plates XXXIV–XXXVII) on which the station positions are marked.

[1] See Harvey, H. W., 1934, *Measurement of Phytoplankton population*, Journ. Mar. Biol. Assoc., N.S. XIX, pp. 761–73.

R.R.S. 'WILLIAM SCORESBY'
PERU CURRENT
STATIONS WS 576–748

17. iv. 1931—16. ix. 1931

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 576	51° 35′ S, 57° 49·8′ W Berkeley Sound, East Falkland	1931 17 iv	0816 0950	34* 24*	SW	4–6	—	0	or	1023·9	7·2	6·7	—
WS 577	51° 13·6′S, 57° 45·4′ W	20 iv	2200	86*	W × S	4–6	W	2	c	1015·1	6·7	6·5	low long W × S swell
WS 578	51° 14·8′ S, 62° 50′ W	21 iv	2105	168*	NW	17–27	NW	4	c	1008·9	9·4	8·3	mod. av. W × N swell
WS 579	52° 19·6′ S, 67° 47′ W	22 iv	2022	79*	NNW	11–16	NNW	3	c	996·9	10·0	8·3	low long swell
WS 580	53° 04·8′ S, 70° 40·7′ W Magellan Strait, off Punta Arenas (Magellanes)	23 iv	1410	102*	SW × W	7–10	SW	1	c	1001·9	10·8	7·8	no swell
WS 581	53° 39′ S, 70° 49′ W Magellan Strait	30 iv	1124	—	SW	34–40	SW	3	bc	1004·5	10·0	8·3	mod. short SW swell
WS 582	53° 42·5′ S, 70° 55′ W Port Famine, Magellan Strait	30 iv	1420 1436 1451 1504 1520 1700	— 110* 223* 198* 112* 12*	SW	11–16	SW	3	c	1007·5	8·6	8·3	low av. SW swell
WS 583	53° 39′ S, 70° 54·5′ W Magellan Strait	2 v	0657 0730	62* 78*	W × N	7–10	W	1–2	c	999·3	10·0	7·8	—
WS 584	53° 55′ S, 71° 16′ W Magellan Strait	2 v	1134	—	WNW	34–47	WNW	4	omrq	991·9	7·2	6·7	mod. short WNW swell
WS 585	53° 31·3′ S, 72° 39·3′ W Magellan Strait	4 v	1340	—	SW	4–6	SW	0–1	or	1007·0	4·4	3·9	—
WS 586	48° 27·5′ S, 74° 23·5′ W Connor Inlet	8 v	1800	22*	—	0	—	0	bc	1008·3	5·6	5·0	—
WS 587	46° 14·5′ S, 75° 55·6′ W	10 v	2000	—	S	7–10	S	4	bc	1023·1	7·2	6·7	mod. long S swell
WS 588	42° 42′ S, 75° 21′ W	11 v	2000	—	E	11–16	SE	3	bc	1031·4	8·9	8·9	mod. av. S × E swell
WS 589	38° 04′ S, 73° 52′ W	15 v	2000	—	W	4–6	—	0	b	1021·5	11·1	8·3	low long S swell
WS 590	1½ cables E of Naval Pier, Talcahuano Harbour, Chile	16 v	1400	8	NE	1–6	—	0	b	1020·0	10·0	8·3	—
WS 591	35° 47′ S, 72° 39′ W	18 v	1258	27 f.gy.S	—	0	—	0	o	1022·9	12·2	10·0	low long SE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 576	0	—	—	—	—	—	—	OTC	34–24	0840	0950	+3 hours. Sandy bottom
WS 577	3	0	8·60	—	—	—	—	N 70 B N 100 B	91–0	**2223**	**2243**	+4 hours KT. Suspected of fishing near bottom
WS 578	4	0	7·80	—	—	—	—	N 100 B N 70 B N 100 B N 50 V	160–0 128–0 100–0	**2113** **2147** **2224**	**2128** **2207** **2226**	KT KT
WS 579	5	0	9·80	—	—	—	—	N 70 B N 100 B N 50 V	79–0 70–0	**2037** **2115**	**2057** **2117**	KT. +5 hours
WS 580	6	0	8·36	—	—	—	—	N 70 B N 100 B N 50 V	90–0 100–0	1422 1453	1444 1455	KT
WS 581	12	0	7·90	—	—	—	—	N 70 B N 100 B	172–0	1144	1205	KT. Strong wind and much lateral drift
WS 582	13	0	7·95	—	—	—	—	BTS LH NH	110 12 12	1436 **1700** **1700**	1531 **1800** **1800**	Trawl did not appear to have fished on the bottom Hand net used frequently during this period
WS 583	14	0	7·90	—	—	—	—	BTS	14–78	0700	0730	Muddy bottom
WS 584	15	0	8·01	—	—	—	—	N 70 B N 100 B	84–0	1148	1208	KT
WS 585	16	0	8·02	—	—	—	—	N 70 B N 100 B N 50 V	140–0 90–0	1353 1422	1413 1424	KT Stray on wire
WS 586	20	0	8·18	12·57	9·76	0·13	—	LH NH	22 0	**1800** **1800**	**2200** **2200**	 Hand net used frequently during this period
WS 587	23	0	11·70	33·37	25·40	0·38	—	N 70 B N 100 B N 50 V	78–0 100–0	**2020** **2058**	**2041** **2100**	KT
WS 588	24	0	12·73	33·35	25·19	0·44	—	N 50 V N 70 B N 100 B N 100 B	100–0 100–0 265–100	**2013** **2035** **2035**	**2015** **2055** **2105**	 Depth estimated Depth estimated
WS 589	28	0	10·67	34·21	26·24	0·61	—	N 50 V N 70 B N 100 B	100–0 91–0	**2009** **2025**	**2011** **2044**	 KT
WS 590	28	0 5	11·20 11·20	34·25 34·32	26·17 26·23	1·24 1·37	— —	N 70 B N 50 B	7–0 7–0	1400 1413	1402 1415	
WS 591	1	0 10 20	11·70 11·20 11·45	34·25 — 34·49	26·08 — 26·31	1·41 1·48 1·33	5·15 — 3·99	N 70 H N 100 H N 50 H	0–5 0–5 0–5	1321 1322 1325	1341 1340 1327	

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 592	35° 46′ S, 72° 42·5′ W	1931 18 v	1351	60*	E	1–6	—	0	bc	1023·0	12·8	10·2	—
WS 593	35° 36′ S, 72° 44′ W	18 v	1622	44*	NW × N	4–6	NW × N	2	o	1022·6	11·7	10·6	low long SW swell
WS 594	35° 36′ S, 72° 50′ W	18 v	1748	55*	Lt airs	0–3	—	0	or	1021·1	11·7	10·6	low long SW swell
WS 595	35° 35·2′ S, 72° 56′ W	18 v	1921	124*	Lt airs	0–3	—	0	o	1022·6	12·2	10·6	low long SW swell
WS 596	35° 35·6′ S, 73° 07·5′ W	18–19 v	2157	369 d.M	Lt airs	0–3	—	0	or	1022·6	12·2	10·6	low short to low long E swell
WS 597	35° 39·7′ S, 73° 19·5′ W	19 v	0630	1593 d.gy.M	NNE	11–16	NNE	3	op	1024·5	11·7	11·2	mod. av. SW swell
WS 598	35° 43′ S, 73° 32′ W	19 v	1025	2308 G.gn.M	NNE	11–16	NNE	3	op	1027·3	11·7	11·1	—

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS: Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	BIOLOGICAL OBSERVATIONS: Gear	Depth (metres)	TIME: From	To	Remarks
WS 592	1	0	11·46	34·39	26·24	2·83	—	**N 50 V**	50–0	1359	1360	
		10	11·32	34·41	26·28	2·60	—	**N 70 B**	41–0	1429	1449	KT
		20	11·30	34·48	26·34	2·59	—	**N 100 B**				
		30	11·27	34·49	26·34	2·57	—					
		40	11·23	34·55	26·41	2·41	—					
		50	11·20	34·56	26·41	2·64	—					
WS 593	1	0	11·45	34·11	26·02	2·05	5·16	**N 50 V**	40–0	1629	1630	
		10	11·45	34·45	26·28	2·32	—	**N 70 B**	30–0	1700	1720	**N 100 B** touched bottom
		20	11·40	34·50	26·33	2·41	2·39	**N 100 B**				
		30	11·38	34·52	26·35	3·14	—					
		37·5	11·37	34·53	26·36	3·33	2·08					
WS 594	1	0	11·69	34·43	26·23	2·41	—	**N 50 V**	40–0	1755	1757	
		10	11·60	34·43	26·24	2·30	—	**N 70 B**	58–0	1832	1855	KT
		20	11·60	34·45	26·25	2·79	—	**N 100 B**				
		30	11·51	34·45	26·27	2·66	—					
		40	11·45	34·51	26·33	2·30	—					
		50	11·40	34·53	26·36	3·14	—					
WS 595	1	0	11·62	34·43	26·24	1·98	3·95	**N 50 V**	100–0	1943		
		10	11·59	34·40	26·22	2·22	—	**N 70 V**	50–0			
		20	11·56	34·38	26·21	2·32	3·73	,,	100–50	—	2015	
		30	11·48	34·46	26·28	2·41	—	**N 70 B**	88–0	2043	2103	KT
		40	11·42	34·53	26·35	2·53	1·12	**N 100 B**				
		50	11·40	34·58	26·40	2·97						
		60	11·41	34·60	26·40	2·97	0·50					
		80	11·26	34·64	26·47	3·14						
		100	11·02	34·63	26·50	3·14	0·29					
WS 596	1	0	11·85	34·29	26·08	2·41	—	**N 50 V**	100–0	2210	2212	
		10	11·89	34·30	26·08	2·41	—	**N 70 B**	91–0	2348	0008	KT
		20	11·80	34·30	26·10	2·41	—	**N 100 B**				
		30	11·56	34·40	26·22	2·66	—	**N 100 B**	240–90	2348	0020	Depth estimated
		40	11·42	34·47	26·31	2·66						
		50	11·51	34·51	26·32	2·79						
		60	11·31	34·55	26·39	2·79						
		80	11·28	34·60	26·43	2·79						
		100	11·27	34·53	26·38	2·66						
		150	10·90	34·65	26·54	2·97						
		200	10·23	34·64	26·65	2·66						
		300	8·83	34·59	26·85	2·66						
WS 597	2	0	12·36	34·23	25·94	1·35	5·66	**N 50 V**	100–0	0643	0645	
		10	12·38	34·23	25·93	1·35	—	**N 70 B**	75–0	0902	0921	KT
		20	12·35	34·24	25·96	1·43	5·58	**N 100 B**				
		30	12·05	34·33	26·07	1·43	—	**N 100 B**	210–75	0902	0931	Depth estimated
		40	11·70	34·49	26·26	1·46	1·40					
		50	12·01	34·68	26·36	3·33						
		60	12·02	34·72	26·39	2·97	0·32					
		80	11·99	34·73	26·40	3·33						
		100	11·48	34·70	26·47	3·14	0·38					
		150	11·35	34·72	26·51	3·33						
		200	11·05	34·73	26·58	2·97	0·41					
		300	9·42	34·61	26·77	2·97						
		400	8·18	34·52	26·89	2·79	1·12					
		600	6·11	34·39	27·08	2·05						
		800	4·74	34·36	27·22	2·40	2·58					
		1000	4·06	34·43	27·34	2·53						
		1500	2·98	34·60	27·59	2·57	3·91					
WS 598	2	0	12·12	34·22	25·97	1·46	—	**N 50 V**	100–0	1156	1158	
		10	12·18	34·34	26·07	1·46	—	**N 70 B**	66–0	1241	1259	KT
		20	12·03	34·32	26·08	1·50	—	**N 100 B**				
		30	11·96	34·36	26·12	1·90	—	**N 100 B**	190–65	1241	1310	Depth estimated

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 598 *cont.*	35° 43′ S, 73° 32′ W	1931 19 v											
WS 599	35° 41·5′ S, 73° 43′ W	19 v	1406	3264 gn.M	ESE	7–10	ESE	2	bc	1025·2	12·8	11·1	mod. short to mod. av. SW swell
WS 600	35° 40′ S, 73° 55′ W	19 v	1915	—	SW	7–10	SW	3	b	1027·3	12·2	11·1	low long SW swell
WS 601	35° 30·5′ S, 74° 18′ W	20 v	0009	5170	SSE	7–10	S	3	b	1025·1	12·2	11·1	low short to low long S swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 598 *cont.*	2	40	11·59	34·47	26·27	2·53						
		50	11·49	34·55	26·36	2·47						
		60	11·48	34·60	26·39	2·66						
		80	11·48	34·69	26·46	2·97						
		100	11·26	34·70	26·52	2·97						
		150	10·92	34·69	26·56	2·97						
		200	10·25	34·66	26·66	2·97						
		300	8·95	34·61	26·84	3·80						
		400	7·23	34·43	26·95	3·55						
		600	4·98	34·34	27·18	3·33						
		800	4·19	34·39	27·31	3·14						
		1000	3·61	34·50	27·45	3·14						
		1500	2·65	34·61	27·64	3·55						
		2000	2·16	34·64	27·70	3·33						
WS 599	2	0	12·87	34·13	25·76	1·63	5·80	N 50 V	100–0	1550	1552	
		10	12·82	34·15	25·80	1·63	—	N 70 B	84–0	1754	1816	Depth estimated
		20	12·59	34·19	25·87	1·77	5·35	N 100 B				
		30	12·58	34·20	25·87	1·90	—	N 100 B	230–85	1754	1822	Depth estimated
		40	12·00	34·12	25·93	1·90	4·89					
		50	11·61	34·07	25·96	1·77						
		60	11·36	34·31	26·19	2·53	4·03					
		80	10·74	34·30	26·30	2·79						
		100	10·68	34·49	26·45	2·79	0·87					
		150	10·30	34·58	26·59	3·14						
		200	9·60	34·58	26·71	3·33	2·51					
		300	8·32	34·50	26·85	3·33						
		400	6·95	34·41	26·98	3·33						
		600	5·31	34·26	27·07	3·33						
		800	4·38	34·31	27·22	3·80	3·88					
		1000	3·77	34·43	27·38	3·80						
		1500	3·04									
		2000	2·55	34·46	27·51	3·80						
		2500	1·92	34·67	27·73	3·80	3·18					
		3000	1·80									
WS 600	2	0	13·57	33·97	25·50	1·98	—	N 50 V	100–0	2100	2102	
		10	12·78	34·11	25·77	2·22	—	N 70 B	99–0	2150	2210	KT
		20	12·20	34·10	25·87	2·22	—	N 100 B				
		30	12·29	34·17	25·91	1·90	—	N 100 B	265–100	2150	2216	Depth estimated
		40	11·31	34·20	26·11	2·53						
		50	11·06	34·21	26·17	2·66						
		60	10·91	34·31	26·27	2·79						
		80	10·82	34·42	26·37	3·14						
		100	10·75	34·49	26·44	3·55						
		150	10·40	34·58	26·58	3·80						
		200	9·67	34·73	26·82	3·80						
		300	8·38	34·52	26·86	3·80						
		400	7·01	34·40	26·96	3·80						
		600	5·27	34·28	27·10	3·55						
		800	4·38	34·33	27·23	3·33						
		1000	3·80	34·36	27·32	3·33						
		1500	2·83	34·49	27·51	3·33						
		2000	2·24	34·61	27·66	3·14						
		2500	1·93	34·64	27·71	3·14						
		3000	1·84	34·67	27·74	3·14						
WS 601	2	0	13·65	33·87	25·41	0·36	3·14	NH	0	0130	0430	Hand net used frequently
		10	13·56	33·87	25·43	0·36	—	N 50 V	100–0	0250	0252	throughout station
		20	13·30	33·91	25·51	0·51	5·78	N 70 B	87–0	0454	0517	KT
		30	13·05	34·02	25·65	0·51	—	N 100 B				
		40	12·80	34·15	25·80	0·80	5·59	N 100 B	230–85	0454	0527	Depth estimated
		50	12·68									
		60	12·53	34·22	25·89	0·87	5·38					
		80	10·72	34·11	26·15	0·87						

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 601 *cont.*	35° 30·5′ S, 74° 18′ W	1931 20 v											
WS 602	32° 04·8′ S, 71° 34′ W	28 v	1308	75 Sh	SSW	4–6	S	2	bc	1020·2	13·9	12·2	mod. long to heavy short WSW swell
WS 603	32° 05′ S, 71° 40′ W	28 v	1502	278 R	SW	4–6	S × W	2	c	1019·7	13·3	12·2	mod. long WSW swell
WS 604	32° 05′ S, 71° 45·5′ W	28 v	1655	688 gy.M	E	4–6	E	2	c	1019·8	13·1	12·2	heavy long WSW swell
WS 605	32° 05′ S, 71° 50′ W	28 v	2037	1297 gy.M	E	4–6	E	2	c	1020·7	13·3	12·8	heavy long WSW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S °/₀₀	σt	P. mg. atom m.³	O_2 c.c. litre	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 601 *cont.*	2	100	10·98	34·30	26·25	1·46	2·15					Position of ship changed
		150	10·62	34·57	26·53	1·54						
		200	9·80	34·44	26·57	1·62	1·06					
		300	8·48	34·49	26·82	1·56						
		400	7·11	34·36	26·92	1·22	4·42					
		600	5·86	34·30	27·04	1·22	—	—	—	—	—	
		800	4·91	34·33	27·17	1·35	4·77	—	—	—	—	
		1000	4·11	34·35	27·29	1·35	—	—	—	—	—	
		1500	3·22	—	—	—	—	—	—	—	—	Heavy stray on wire
		2000	2·62	34·59	27·62	1·50	—	—	—	—	—	
		2500	2·13	34·66	27·71	1·50	2·92	—	—	—	—	
		3000	1·79	34·68	27·75	1·35	—	—	—	—	—	
WS 602	11	0	14·02	34·24	25·62	0·68	5·59	**N 50 V**	50–0	1335	1357	
		10	13·20	34·24	25·79	—	—	**N 70 B**	65–0	1358	1418	KT
		20	12·30	34·30	26·00	1·18	3·06	**N 100 B**				
		30	12·17	34·36	26·08							
		40	12·08	34·38	26·11	1·50	4·24					
		50	11·92	34·43	26·18							
		60	11·79	34·50	26·26	1·63	1·95					
WS 603	11	0	14·32	34·27	25·57	—	—	**N 50 V**	100–0	1535	1537	
		10	14·26	34·27	25·59	—	—	**N 70 B**	99–0	1557	1618	KT
		20	13·90	34·26	25·65	0·13	—	**N 100 B**				
		30	13·10	34·24	25·81							
		40	12·00	34·13	25·93	0·86						
		50	11·10	34·17	26·13							
		60	10·74	34·23	26·24	1·41						
		80	10·60	34·34	26·36							
		100	10·50	34·43	26·44	1·75						
		150	10·67	34·61	26·56							
		200	10·31	34·66	26·65	2·24						
		250	9·83	34·63	26·71							
WS 604	11	0	14·00	34·26	25·63	0·21	5·50	**N 50 V**	100–0	**1853**	**1855**	
		10	13·90	34·25	25·65	—	—	**N 70 B**	73–0	**1937**	**1957**	KT
		20	13·87	34·24	25·65	0·21	5·43	**N 100 B**				
		30	13·85	34·24	25·66	—	—	**N 100 B**	205–75	**1937**	**2005**	Depth estimated
		40	13·70	34·26	25·69	0·48	5·28					
		50	12·15	34·09	25·87							
		60	11·60	34·07	25·96	0·68	4·67					
		80	10·73	34·19	26·22							
		100	10·60	34·35	26·37	1·56	2·29					
		150	10·54	34·60	26·56							
		200	10·20	34·65	26·66	1·98	0·41					
		300	8·56	34·53	26·84							
		400	7·12	34·47	27·01	1·90	1·97					
		600	5·27	34·34	27·14	—	3·99					
WS 605	11	0	13·91	34·22	25·61	0·13	—	**N 50 V**	100–0	**2155**	**2157**	
		10	13·89	34·22	25·62	—	—	**N 70 B**	74–0	**2225**	**2245**	KT
		20	13·88	34·23	25·63	0·13	—	**N 100 B**				
		30	13·87	34·22	25·62	—	—	**N 100 B**	205–75	**2225**	**2254**	Depth estimated
		40	13·82	34·21	25·63	0·40						
		50	12·86	34·15	25·79							
		60	12·06	34·09	25·89	0·82						
		80	10·86	34·15	26·17							
		100	11·00	34·44	26·36	2·07						
		150	10·90	34·66	26·55							
		200	10·33	34·66	26·65	2·47						
		300	8·62	34·52	26·82							
		400	7·07	34·43	26·98	2·13						
		600	5·31	34·34	27·13							
		800	4·46	34·38	27·27	2·24						
		1000	3·84	34·42	27·35							

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 606	32° 09·6′ S, 73° 32′ W	1931 29 v	0745	3530	S	7–10	S	2	bc	1021·8	15·3	15·1	heavy long WSW swell
WS 607	32° 05·5′ S, 74° 04′ W	29 v	1716	—	S	11–16	S	3	o	1020·1	15·0	12·8	heavy long SW swell
WS 608	31° 57·5′ S, 73° 02′ W	30 v	0440	—	S	17–27	S	4	o	1017·5	13·9	11·9	heavy short S swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 606	12	0	16·20	34·19	25·10	0·48	5·57	N 70 V	50–0	0920		
		10	16·19	34·19	25·11	—	—	,,	100–50			
		20	16·09	34·18	25·12	0·55	5·55	,,	250–100			
		30	16·03	34·19	25·14	—	—	,,	500–250	—	1100	
		40	16·00	34·19	25·15	0·61	5·47	,,	1000–750	1200		
		50	15·99	34·18	25·14	—	—	,,	750–500	—	1355	
		60	15·95	34·17	25·14	0·68	5·52	N 50 V	120–0	1358	1400	
		80	12·57	34·05	25·76	—	—	N 70 B	75–0	1422	1442	KT
		100	11·65	34·12	25·99	1·06	4·76	N 100 B				
		150	10·52	34·29	26·32	—	—	N 100 B	210–75	1422	1447	Depth estimated
		200	10·33	34·61	26·62	2·68	0·68					
		300	8·78	34·53	26·81							
		400	7·87	34·43	26·87	2·47	1·41					
		600	6·04	34·34	27·04							
		800	4·93	34·28	27·14	2·36	4·01					
		1000	4·22	34·37	27·29							
		1500	3·97	34·55	27·46	2·47	2·39					
		2000	3·77	34·41	27·36							
		2500	3·33	34·50	27·47	2·60	2·50					
		3000	2·95	34·51	27·52							
		3500	2·81	34·54	27·56	2·60	2·62					
WS 607	12	0	16·42	34·27	25·11	0·40	—	N 50 V	100–0	1838	1840	
		10	16·44	34·28	25·11	—	—	N 70 B	83–0	2118	2139	KT
		20	16·44	34·28	25·11	0·40	—	N 100 B				
		30	16·44	34·28	25·11	—	—	N 100 B	225–85	2118	2150	Depth estimated
		40	16·43	34·35	25·17	0·40						
		50	16·22	34·24	25·14							
		60	16·01	34·26	25·19	0·40						
		80	12·50	34·11	25·82							
		100	11·49	34·18	26·07	1·22						
		150	10·60	34·40	26·40							
		200	9·86	34·49	26·59	2·15						
		300	7·88	34·58	26·98							
		400	6·40	34·41	27·06	2·24						
		600	5·05	34·42	27·22							
		800	4·41	34·41	27·29	2·05						
		1000	3·75	34·41	27·36							
		1500	2·87	34·54	27·56	2·05						
		2000	2·42	34·61	27·64							
		2500	2·03	34·60	27·67	2·05						
		3000	1·86	34·71	27·78							
		3500	1·80	34·44	27·57	2·15						
WS 608	12	0	14·01	34·19	25·58	0·40	—	N 50 V	100–0	0630	0632	
		10	14·01	34·15	25·55	—	—	N 70 B	88–0	0828	0847	KT
		20	14·01	34·16	25·55	0·40	—	N 100 B				
		30	13·77	34·18	25·62	—	—	N 100 B	235–90	0828	0856	Depth estimated
		40	13·61	34·33	25·76	0·55						
		50	13·50	34·21	25·70							
		60	13·32	34·20	25·72	0·82						
		80	12·08	34·28	26·04							
		100	11·52	34·37	26·21	1·50						
		150	10·50	34·47	26·47							
		200	10·13	34·56	26·60	2·24						
		300	9·00	34·56	26·79							
		400	8·34	34·50	26·85	2·36						
		600	8·46	34·55	26·88							
		800	6·90	34·42	26·99	2·36						
		1000	5·58	34·31	27·08							
		1500	4·56	34·44	27·31	2·13						
		2000	3·45	34·55	27·51							
		2500	2·41	34·61	27·66	2·13						
		3000	2·04	34·64	27·71							
		3500	1·88	34·70	27·77	2·13						

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 609	31° 51·2′ S, 72° 34′ W	1931 30 v	1120	—	S	17–27	S	4	o	1016·9	13·3	11·7	heavy short S swell
WS 610	31° 45·5′ S, 72° 01·5′ W	30 v	1840	2487 br.M	S	7–10	S	4	o	1018·1	13·3	11·7	heavy av. S × W swell
WS 611	29° 11′ S, 71° 42·5′ W	3 vi	2000	—	NE	4–6	—	0	b	1018·4	14·4	14·4	low long SW swell
WS 612	27° 08·5′ S, 72° 01·5′ W	4 vi	1117	5861 R	WSW	4–6	SW	3	b	1017·6	16·1	13·9	low long WSW swell
		6 vi	1701	—	W	4–6	W	1	c	1019·3	15·0	14·9	low long WSW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 609	12	0	14·25	34·28	25·60	0·55	5·63	N 50 V	100–0	1315	1317	
		10	14·24	34·29	25·60	—	—	N 70 V	50–0	1325		
		20	14·24	34·25	25·57	0·61	5·47	,,	100–50			
		30	14·20	34·25	25·58	—	—	,,	250–100			
		40	13·90	34·25	25·65	0·61	5·42	,,	500–250			
		50	13·60	34·29	25·74	—	—	,,	750–500			
		60	12·14	34·27	26·02	0·87	4·17	,,	1000–750			
		80	11·16	34·26	26·19	—	—	,,	250–200	—	1525	
		100	10·78	34·27	26·27	1·50	2·72	N 70 B	86–0	1546	1606	KT
		150	11·35	34·73	26·52	—	—	N 100 B				
		200	10·70	34·67	26·59	1·77	0·54	N 100 B	230–85	1546	1614	Depth estimated
		300	9·11	34·59	26·80							
		400	7·75	34·44	26·90	1·98	1·45					
		600	5·72	34·27	27·03							
		800	4·69	34·34	27·21	2·15	3·02					
		1000	4·11	34·41	27·33							
		1500	2·99	34·53	27·54	2·05	2·33					
		2000	2·43	34·57	27·61							
		2500	2·03	34·57	27·65	1·98	2·99					
		3000	1·87	34·63	27·71							
		3500	1·83	34·63	27·71	1·98	3·06					
WS 610	13	0	14·00	34·25	25·62	0·70	—	N 50 V	100–0	**2018**	**2020**	
		10	14·00	34·25	25·62	—	—	N 70 B	56–0	**2100**	**2120**	KT
		20	14·00	34·23	25·60	0·78	—	N 100 B				
		30	14·00	34·23	25·60	—	—	N 100 B	170–55	**2100**	**2127**	Depth estimated
		40	13·96	34·21	25·60	0·63						
		50	13·49									
		60	11·85	34·02	25·88	0·84						
		80	11·90	34·21	26·01							
		100	11·11	34·31	26·24	1·33						
		150	10·50	34·55	26·54							
		200	10·28	34·62	26·64	1·82						
		300	9·00	34·56	26·79							
		400	7·50	34·46	26·94	2·47						
		600	5·42	34·42	27·18							
		800	4·66	34·46	27·31	2·60						
		1000	4·14	34·61	27·49							
		1500	2·85	34·33	27·38	1·56						
		2000	2·26	34·55	27·62							
		2500?	1·92	—	—	—	—	—	—	—	—	Water-bottle struck bottom
WS 611	17	0	15·03	34·60	25·67	—	—	N 70 B	87–0	**2024**	**2045**	KT
								N 100 B				
								N 100 B	230–85	**2024**	**2054**	Depth estimated
								N 50 V	100–0	**2108**	**2110**	
WS 612	18	0	16·61	34·43	25·18	0·13	5·37	N 50 V	100–0	1655	1657	Position re-visited on 6. vi. 31 when observations from 3500 m. to bottom were taken
		10	16·58	34·45	25·20	0·13	—	N 70 V	50–0	1710		
	20	20	16·55	34·45	25·21	0·13	5·35	,,	100–50			
		30	16·53	34·43	25·20	0·13	—	,,	250–50	—	**1730**	
		40	16·50	34·43	25·22	0·13	5·28	,,	250–0	**2010**		
		50	16·48	34·45	25·23	0·13	—	,,	250–100			
		60	15·47	34·38	25·41	0·70	5·15	,,	500–250			
		80	13·02	34·33	25·88	1·27	—	,,	750–500			
		100	12·34	34·30	26·00	1·27	3·10	,,	1000–750	—	**2230**	
		150	11·83	34·65	26·36	1·56	—	N 70 B	69–0	**2253**	**2315**	KT
		200	11·32	34·73	26·53	2·03	0·26	N 100 B				
		300	9·57	34·62	26·76	—	—	N 100 B	195–70	**2253**	**2328**	Depth estimated
		400	8·10	34·52	26·90	2·13	0·91					
		600	5·91	34·37	27·09							
		800	5·05	34·41	27·22	2·20	1·85					
		1000	4·24	34·45	27·34							
		1500	3·74	34·46	27·40	2·13	1·88					
		2000	2·65	34·58	27·61							
		2500	2·17	34·63	27·69	2·13	2·90					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 612 *cont.*	27° 08·5′ S, 72° 01·5′ W	1931 6 vi											
WS 613	27° 05·5′ S, 70° 58′ W	5 vi	0640	134 f.d.S	ESE	4–6	ESE	1	c	1018·4	12·8	11·1	low long SW swell
WS 614	27° 06·5′ S, 71° 00·7′ W	5 vi	0826	296 bl.G	ESE	4–6	ESE	1	c	1018·2	11·7	11·1	low long SW swell
WS 615	27° 05·5′ S, 71° 04′ W	5 vi	1119	1132 R	ESE	4–6	ESE	1	c	1018·1	15·6	12·8	low long SW swell
WS 616	27° 08′ S, 71° 10′ W	5 vi	1511	1768 gn.M	WNW	1–6	—	0	b	1016·5	15·0	12·8	low long SW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 612 *cont.*	18	3000	1·83	34·66	27·73							
		3500	1·74	34·70	27·77	2·79	2·92	—	—	—	—	Phosphate results estimated 4 days later
		4000	1·72	34·71	27·79	—	—	—	—	—	—	
		4500	1·75	34·70	27·77	2·53	—	—	—	—	—	
		5000	1·77	34·66	27·74							
		5500	1·81	34·68	27·75	2·13						
WS 613	19	0	13·10	34·35	25·90	1·41	—	**N 50 V**	100–0	0735	0737	
		10	13·10	34·37	25·91	—	—	**N 70 B**	84–0	0750	0814	KT
		20	12·92	34·50	26·04	1·50	—	**N 100 B**				
		30	12·69	34·56	26·13							
		40	12·60	34·68	26·24	2·34						
		50	12·55	34·70	26·26							
		60	12·51	34·72	26·29	2·45						
		80	12·46	34·74	26·32							
		100	12·28	34·78	26·38	2·45						
		130	12·00	34·80	26·46	2·57						
WS 614	19	0	13·45	34·31	25·79	1·20	—	**N 50 V**	100–0	0830	0832	
		10	13·45	34·36	25·82	1·22	—	**N 70 V**	50–0	0955		
		20	13·40	34·35	25·83	1·22	4·79	,,	100–50			
		30	12·66	34·59	26·16	1·82	—	,,	290–100	—	1015	
		40	12·52	34·72	26·29	2·05	4·54	**N 70 B**	86–0	1039	1059	KT
		50	12·49	34·76	26·32	2·24	—	**N 100 B**				
		60	12·45	34·77	26·34	2·20	0·48	**N 100 B**	230–85	1039	1106	Depth estimated
		80	12·38	34·84	26·41	2·20						
		100	12·31	34·79	26·39	2·20	0·43					
		150	11·87	34·83	26·50	2·24						
		200	11·43	34·79	26·55	2·24	0·23					
		284	10·35	34·85	26·79							
WS 615	19	0	14·20	34·31	25·63	1·03	—	**N 50 V**	100–0	1301	1303	
		10	14·21	34·34	25·65	1·03	—	**N 70 B**	69–0	1320	1340	KT
		20	13·50	34·37	25·82	1·16	—	**N 100 B**				
		30	12·90	34·50	26·04	1·63	—	**N 100 B**	195(–0)	1415	1445	Depth estimated
		40	12·74	34·61	26·16	1·90						
		50	12·46	34·62	26·23	2·15						
		60	12·36	34·68	26·29	2·05						
		80	12·40	34·76	26·34	2·05						
		100	12·21	34·79	26·41	2·05						
		150	11·91	34·76	26·43	2·47						
		200	11·40	34·77	26·54	2·60						
		300	10·94	34·76	26·61							
		400	10·78	34·75	26·65	2·60						
		600	6·04	34·41	27·10							
		800	4·99	34·46	27·27	2·85						
		1000	4·25	34·48	27·37							
WS 616	19	0	14·88	34·34	25·51	1·08	4·87	**N 50 V**	100–0	1655	1657	
		10	13·90	34·32	25·70	1·35	—	**N 70 B**	125–0	1723	1743	KT
		20	13·35	34·36	25·84	1·43	4·63	**N 100 B**				
		30	13·00	34·35	25·92	1·82	—	**N 100 B**	260–125	1723	1743	Depth estimated. Fished on 400 m. of warp closed after 20 min. of tow
		40	12·62	34·40	26·02	1·63	2·65					
		50	12·60	34·56	26·15	2·07						
		60	12·70	34·65	26·19	2·40	1·10					
		80	12·40	34·71	26·31	2·53						
		100	12·22	34·77	26·38	2·85	0·32					
		150	11·90	34·83	26·49	2·68						
		200	11·25	34·78	26·58	2·53	0·26					
		300	10·39	34·74	26·70							
		400	8·75	34·60	26·86	2·53	0·49					
		600	6·02	34·41	27·10							
		800	4·96	34·43	27·25	2·28	2·12					
		1000	4·18	34·52	27·41							
		1500	2·91	34·58	27·58	2·28	2·67					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 617	27° 09·5′ S, 71° 15·7′ W	1931 5 vi	1820	3032 gn.M	WNW	4–6	WNW	2	b	1018·0	13·9	12·8	low long WNW swell
WS 618	27° 09′ S, 71° 12·5′ W	5 vi	2250	—	WNW	1–3	W	1	b	1018·7	13·9	12·8	low long WNW swell
WS 619	27° 03·5′ S, 71° 30′ W	6 vi	0440	4865 lt.br.M	NNW	4–6	NNW	1	bc	1020·1	14·2	12·8	low long WSW swell
WS 620	27° 04·5′ S, 71° 23′ W	6 vi	1150	—	ENE	4–6	ENE	2	bc	1020·8	16·1	13·3	low long SSW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 617	19	0	15·90	34·44	25·36	0·95	—	**N 50 V**	100–0	**1825**	**1827**	
		10	15·90	34·44	25·36	0·95	—	**NH**	0	**2000**		
		20	15·65	34·44	25·42	0·95	—	**N 70 B**	67–0	**2204**	**2225**	KT
		30	14·50	34·34	25·58	1·08	—	**N 100 B**				
		40	13·40	34·25	25·75	1·50	—	**N 100 B**	190–65	**2204**	**2232**	Depth estimated
		50	12·41	34·21	25·92	1·56						
		60	12·45	34·35	26·02	1·77						
		80	11·72	34·36	26·16	2·22						
		100	12·01	34·59	26·29	2·22						
		150	11·76	34·76	26·46	2·66						
		200	11·13	34·74	26·57	2·41						
		300	9·82	34·67	26·74							
		400	8·26	34·56	26·91	2·97						
		600	5·93	34·38	27·10							
		800	4·91	34·44	27·27	2·97						
		1000	4·20	34·50	27·39							
		1500	2·97	34·59	27·59	2·53						
		2000	2·22	34·65	27·69							
		2500	1·90	34·63	27·71	2·66						
		3000	1·85	34·65	27·72							
WS 618	19	0	15·10	34·36	25·47							
		10	14·22	34·28	25·61							
		20	13·80	34·35	25·75							
		30	13·62	34·36	25·79							
		40	13·00	34·41	25·95							
		50	12·54	34·44	26·07							
		60	12·89	34·70	26·20							
		80	12·50	34·67	26·25							
		100	12·60	34·83	26·36							
		150	11·91	34·81	26·48							
		200	11·10	34·78	26·61							
WS 619	20	0	16·56	34·49	25·24	0·63	5·25	**N 50 V**	100–0	**0608**	**0610**	
		10	16·49	34·50	25·27	—	—	**N 70 B**	84–0	1046	1107	KT
		20	16·49	34·49	25·26	0·63	5·29	**N 100 B**				
		30	16·35	34·46	25·27	—	—	**N 100 B**	225–85	1046	1113	Depth estimated
		40	16·16	34·45	25·30	0·63	5·28					
		50	15·88	34·43	25·35							
		60	14·79	34·32	25·51	1·06	5·04					
		80	12·83	34·23	25·85							
		100	11·98	34·35	26·11	1·56	2·15					
		150	11·20	34·55	26·41	2·15						
		200	10·72	34·67	26·59	2·47	0·63					
		300	9·50	34·65	26·78							
		400	7·83	34·52	26·94	2·62	0·88					
		600	5·84	34·42	27·13							
		800	4·86	34·43	27·26	2·62	1·98					
		1000	4·12	34·49	27·38							
		1500	2·86	34·58	27·59	2·34	2·68					
		2000	2·20	34·65	27·69							
		2500	1·89	34·65	27·72	1·77	2·97					
		3000	1·80	34·69	27·75							
		3500	1·79	34·66	27·73	1·90	2·97					
		4000	1·78	34·68	27·76							
		4500	1·69	34·68	27·76	1·86	3·49					
WS 620	20	0	16·50	34·45	25·22	0·72	—	**N 70 B**	69–0	1312	1332	KT
		10	16·21	34·44	25·29	0·72	—	**N 100 B**				
		20	16·18	34·44	25·30	0·72	—	**N 100 B**	195–70	1312	1337	Depth estimated
		30	15·80	34·52	25·44	0·80						
		40	14·91	34·34	25·51	1·24						
		50	14·28	34·31	25·61	1·24						
		60	13·13	34·22	25·77	1·39						
		80	11·92	34·24	26·04	1·56						
		100	11·80	34·50	26·25	2·15						

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 620 *cont.*	27° 04·5′ S, 71° 23′ W	1931 6 vi											
WS 621	24° 27·5′ S, 70° 43′ W	7 vi	2000	—	S	11–21	S	3	bc	1021·5	15·6	13·9	mod. av. S swell
WS 622	23° 32·6′ S, 70° 38·5′ W	8 vi	0810	148 br.v.M	E	11–16	SSW	3	bc	1018·6	13·9	11·7	low long E swell
WS 623	23° 32·7′ S, 70° 41′ W	8 vi	1029	289 S.G	E	11–16	SSW	3	bc	1018·7	16·1	13·3	low long E swell
WS 624	23° 31·8′ S, 70° 44·5′ W	8 vi	1315	819 R	S	7–10	S	3	b	1016·4	16·1	13·9	mod. short S swell
WS 625	23° 31·7′ S, 70° 47′ W	8 vi	1520	1039	S	7–16	S	3–4	b	1015·4	16·1	13·9	mod. short S swell

Station	Age of moon (days)	Hydrological observations						Biological observations				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.^{3}	O_2 c.c. litre	Gear	Depth (metres)	Time From	Time To	
WS 620 *cont.*	20	150	11·07	34·59	26·47	2·22						
		200	10·37	34·68	26·66	2·45						
		300	9·23	34·61	26·79							
WS 621	21	0	17·20	34·79	25·33	—	—	**N 70 B**	73–0	**2020**	**2040**	KT
								N 100 B				
								N 100 B	205–75	**2020**	**2050**	Depth estimated
								N 50 V	100–0	**2058**	**2100**	
WS 622	22	0	14·10	34·59	25·87	—	4·39	**N 50 V**	100–0	0935	0937	
		10	14·07	34·59	25·88	—	—	**N 70 B**	128–0	0953	1013	KT
		20	13·70	34·81	26·13	—	—	**N 100 B**				
		30	13·44	34·74	26·12							
		40	13·38	34·77	26·15	—	1·12					
		50	13·26	34·80	26·21							
		60	12·79	34·84	26·33	—	0·26					
		80	12·70	34·87	26·37							
		100	12·60	34·86	26·38	—	0·34					
WS 623	22	0	14·14	34·64	25·90	—	—	**N 50 V**	100–0	1030	1032	
		10	13·69	34·70	26·03	—	—	**N 70 V**	50–0	1140		
		20	13·73	34·76	26·07	—	—	,,	100–50			
		30	13·61	34·76	26·10	—	—	,,	280–100	—	1210	
		40	13·51	34·79	26·15	—	—	**N 70 B**	95–0	1232	1254	KT
		50	13·27	34·80	26·21	—	—	**N 100 B**				
		60	13·19	34·80	26·22	—	—	**N 100 B**	250–95	1232	1259	Depth estimated
		80	13·04	34·84	26·28							
		100	12·61	34·89	26·40							
		150	12·33	34·86	26·43							
		200	11·81	34·88	26·55							
		250	11·67	34·88	26·58							
WS 624	22	0	14·31	34·56	25·80	1·90	3·51	**N 50 V**	100–0	1420	1422	
		10	14·08	34·63	25·90	1·98	—	**N 70 B**	102–0	1446	1506	KT
		20	13·81	34·72	26·03	2·32	2·13	**N 100 B**				
		30	13·68	34·77	26·09	2·66	—	**N 100 B**	265–100	1446	1512	Depth estimated
		40	13·26	34·80	26·21	2·32	0·46					
		50	13·14	34·80	26·23	2·41						
		60	12·94	34·80	26·27	2·41	0·18					
		80	12·71	34·82	26·34	2·41						
		100	12·71	34·93	26·41	2·53	0·21					
		150	12·29	34·83	26·42	2·53						
		200	11·95	34·80	26·47	2·66	0·20					
		300	11·08	34·78	26·61	2·41						
		400	9·38	34·64	26·80	2·41	0·30					
		600	6·26	34·42	27·07							
		750	5·33	34·46	27·23	2·32	1·72					
WS 625	22	0	13·93	34·39	25·75	1·39	—	**N 50 V**	100–0	1520	1522	
		10	13·72	34·49	25·86	1·39	—	**N 70 B**	109–0	1653	**1713**	KT
		20	13·46	34·42	25·86	1·54	—	**N 100 B**				
		30	13·62	34·63	26·00	1·98	—	**N 100 B**	300–110	1653	**1723**	Depth estimated
		40	13·32	34·79	26·19	2·34						
		50	13·23	34·79	26·20	2·15						
		60	13·06	34·75	26·21	2·22						
		80	12·91	34·81	26·29	2·22						
		100	12·76	34·82	26·33	2·34						
		150	12·44	34·82	26·39	2·34						
		200	11·98	34·88	26·52	2·45						
		300	11·23	34·80	26·60							
		400	9·40	34·66	26·80	2·45						
		600	7·38	34·53	27·02							
		800	5·47	34·47	27·22	2·45						
		950	4·72	34·47	27·31							

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 626	23° 30′ S, 70° 50′ W	1931 8 vi	1734	1940 R	S	11–16	S	3	b	1014·6	14·4	12·8	mod. av. SW swell
WS 627	23° 28′ S, 70° 52·5′ W	8 vi	2034	2195 R	S	11–16	S	3	b	1016·4	14·4	12·8	mod. av. SW swell
WS 628	23° 25′ S, 70° 55′ W	8–9 vi	2354	—	S	11–16	S	3	b	1015·2	15·0	12·8	mod. av. S swell
WS 629	23° 21·5′ S, 71° 28′ W	9 vi	0840	7154	SSW	17–21	S	4	b	1016·6	15·6	13·9	mod. av. S swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 626	22	0	14·09	34·41	25·73	1·77	4·75	N 50 V	100–0	1912	1914	
		10	14·11	34·46	25·76	1·56	—	N 70 B	87–0	1950	2010	KT
		20	14·09	34·49	25·79	1·56	4·64	N 100 B				
		30	13·20	34·55	26·03	2·24	—	N 100 B	230–85	1950	2020	Depth estimated
		40	13·61	34·81	26·14	2·47	0·82					
		50	13·16	34·72	26·16	2·47						
		60	13·07	34·79	26·24	2·74	0·28					
		80	12·81	34·90	26·38	3·10						
		100	12·71	35·02	26·49	3·10	0·14					
		150	12·18	34·82	26·44	2·91						
		200	11·65	34·79	26·51	3·10	0·18					
		300	10·85	34·73	26·61							
		400	9·48	34·66	26·79	2·74	0·26					
		600	6·29	34·44	27·10							
		800	4·98	34·45	27·26	3·10						
		1000	4·27	34·48	27·37							
		1500	3·85	34·59	27·50	2·91						
WS 627	22	0	15·01	34·51	25·61	1·29	—	N 50 V	100–0	2035	2037	
		10	15·02	34·52	25·62	1·29	—	N 70 B	69–0	2305	2325	KT
		20	14·85	34·68	25·78	1·35	—	N 100 B				
		30	13·91	34·52	25·85	1·56	—	N 100 B	195–70	2305	2335	Depth estimated
		40	13·16	34·48	25·98	1·82						
		50	12·42	34·49	26·13	2·15						
		60	13·34	34·86	26·23	2·47						
		80	13·03	34·84	26·28	2·36						
		100	12·73	34·87	26·36	2·47						
		150	12·22	34·87	26·46	2·60						
		200	11·60	34·83	26·55	2·74						
		300	11·07	34·81	26·64							
		400	9·67	34·67	26·77	2·74						
		600	6·92	34·48	27·04							
		800	5·27	34·44	27·23	2·74						
		1000	4·51	34·49	27·34							
		1500	3·14	34·57	27·55	2·91						
WS 628	22	0	15·19	34·54	25·60	1·90						
		10	15·20	34·53	25·59							
		20	15·15	34·51	25·58	1·77						
		30	13·92	34·48	25·82							
		40	13·12	34·48	25·99	2·05						
		50	12·77	34·49	26·06							
		60	12·18	34·47	26·16	1·90						
		80	12·01	34·59	26·29							
		100	12·32	34·77	26·37	2·97						
		150	12·10	34·82	26·46							
		200	11·57	—	—	2·66						
		300	11·00	34·79	26·63							
		400	9·70	34·70	26·78	2·66						
		600	7·42	34·54	27·02							
		800	5·38	34·50	27·25							
		1000	4·55	34·45	27·31							
WS 629	23	0	18·04	34·87	25·18	0·82	5·02	N 50 V	100–0	1050	1052	
		10	18·03	34·87	25·18	—	—	N 70 V	50–0	1100		
		20	18·02	34·87	25·18	0·82	5·14	,,	100–50			
		30	18·02	34·86	25·17	—	—	,,	250–100			
		40	18·00	34·86	25·18	0·82	5·19	,,	500–250	—	1145	
		50	17·97	34·81	25·16	—	—	N 70 B	87–0	1736	1756	KT
		60	17·92	34·80	25·16	0·95	5·03	N 100 B				
		70	16·16	—	—	—	—	N 100 B	230–85	1736	1807	Depth estimated
		80	14·71	34·35	25·56							
		100	12·57	34·31	25·96	1·16	1·35					
		150	10·92	34·46	26·39							
		200	11·00	34·70	26·57	1·69	1·82					
		300	9·87	34·67	26·74							
		400	8·74	34·60	26·86	1·90	0·32					

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 629 *cont.*	23° 21·5′ S, 71° 28′ W	1931 9 vi											
WS 630	From 23° 22′ S, 71° 06′ W	9–10 vi	1955	—	S	7–10	S	2	b	1015·7	15·0	13·9	mod. av. S swell
	to 23° 13·5′ S, 70° 56′ W		0400	—	NE	4–6	NE	2	c	1015·1	14·4	12·5	mod. av. S swell
WS 631	23° 12′ S, 70° 49′ W	10 vi	0838	—	NE	4–6	NE	2	c	1016·2	13·9	12·8	low short to low long SW swell
WS 632	23° 10′ S, 70° 46·5′ W	10 vi	1104	—	NE	4–6	NE	2	c	1015·6	14·4	12·8	low long SE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 629 *cont.*	23	600	7·26	34·60	27·08							
		800	5·81	34·42	27·13	2·22	1·60					
		1000	4·96	34·52	27·32							
		1500	3·84	34·50	27·42	2·22	1·55					
		2000	2·79	34·56	27·57							
		2500	2·21	34·67	27·71	2·05	2·55					
		3000	1·92	34·67	21·73							
		3500	1·76	34·70	27·78	2·22	3·02					
		4000	1·76	34·68	27·76							
		4500	1·75	34·70	27·77	2·41						
WS 630	23	0	17·31	34·70	25·23	0·87	—	**N 70 B**	73–0	**2007**	**2028**	KT
		10	17·31	34·70	25·23	—	—	**N 100 B**				
	24	20	17·29	34·72	25·25	0·87	—	**N 100 B**	205–75	**2007**	**2036**	Depth estimated
		30	17·30	34·71	25·25	—	—	**N 50 V**	100–0	**2045**	**2047**	
		40	17·28	34·70	25·24	0·95						
		50	16·47	34·59	25·35							
		60	14·46	34·37	25·62	1·08						
		80	13·09	34·30	25·85							
		100	11·90	34·30	26·08	1·63						
		150	11·65	34·70	26·44							
		200	11·44	34·83	26·58							
		300	10·02	34·66	26·70							
		400	8·58	34·59	26·89	2·53						
		600	6·36	34·60	27·21							
		800	5·01	34·47	27·28							
		1000	4·31	34·48	27·36							
		1500	2·82	34·58	27·59	2·79						
		2000	2·33	34·62	27·67							
		2500	1·84	34·65	27·72							
		3000	1·82	34·65	27·72							
		3500	1·79	34·67	27·74	2·41						
WS 631	24	0	16·50	34·64	25·38	0·82	—	**N 50 V**	100–0	0955	0957	
		10	16·40	34·64	25·40	—	—	**N 70 B**	53–0	1028	1048	KT
		20	15·67	34·58	25·52	0·87	—	**N 100 B**				
		30	15·19	34·52	25·58	—	—	**N 100 B**	140–55	1028	1056	Depth estimated
		40	14·86	34·49	25·62	1·22						
		50	13·68	34·34	25·77							
		60	12·66	34·29	25·92	1·50						
		80	12·22	34·43	26·12							
		100	12·08	34·58	26·27	2·22						
		150	11·98	34·82	26·48							
		200	11·68	34·83	26·54	2·53						
		300	10·38	34·77	26·72							
		400	8·95	34·68	26·90	2·53						
		600	6·21	34·59	27·23							
		800	5·12	34·45	27·24	2·66						
		1000	4·39	34·51	27·37							
		1500	2·83	34·50	27·52	2·97						
WS 632	24	0	15·77	34·53	25·46	0·82	5·27	**N 50 V**	100–0	1225	1227	
		10	15·66	34·54	25·49	—	—	**N 70 B**	95–0	1245	1306	KT
		20	15·31	34·50	25·53	0·95	5·34	**N 100 B**				
		30	14·80	34·43	25·59	—	—	**N 100 B**	250–95	1245	1310	Depth estimated
		40	13·68	34·29	25·72	1·03	4·59					
		50	12·91	34·28	25·88							
		60	12·86	34·40	25·97	1·29	2·89					
		80	13·21	34·77	26·19							
		100	12·73	34·78	26·29	2·22	0·56					
		150	12·12	34·81	26·44							
		200	11·64	34·81	26·53	2·34	0·10					
		300	10·38	34·70	26·67							
		400	9·24	34·45	26·67	2·34	0·23					
		600	6·36	34·60	27·21							
		800	5·20	34·48	27·26	2·70	1·69					
		1000	4·29	34·48	27·37	—	0·92					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 633	23° 10′ S, 70° 43·5′ W	1931 10 vi	1323	—	N × W	4–10	W	2–3	bc	1015·3	15·6	12·8	low long SE swell
WS 634	23° 10′ S, 70° 40·5′ W	10 vi	1523	—	N × W	7–10	W	2–3	bc	1014·2	15·0	12·8	low long W swell
WS 635	23° 12·5′ S, 70° 39·5′ W	10 vi	1658	700	N × W	11–16	N × W	3	b	1015·7	14·4	12·2	low short S swell
WS 636	22° 04·5′ S, 70° 36′ W	16 vi	2000	—	WSW	7–10	WSW	3	b	1015·9	15·0	14·4	mod. short SW swell
WS 637	19° 48′ S, 70° 22′ W	18 vi	2000	—	NNW	4–6	NNW	2	bc	1017·7	15·6	15·0	low long SW swell
WS 638	18° 54·5′ S, 71° 06′ W	19 vi	0508	2277 gy.Oz	SE	7–10	SE	3	o	1016·7	16·1	13·9	low long SE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S °/₀₀	σt	P. mg. atom m.³	O₂ c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 633	24	0	15·85	34·54	25·45	—	—	**N 50 V**	100–0	1325	1327	
		10	15·61	34·51	25·47	—	—	**N 70 B**	76–0	1440	1500	KT
		20	13·98	34·46	25·79	—	—	**N 100 B**				
		30	13·81	34·58	25·92	—	—	**N 100 B**	210–75	1440	1507	Depth estimated
		40	14·00	34·74	26·01							
		50	13·94	34·68	25·97							
		60	13·76	34·79	26·10							
		80	13·40	34·84	26·21							
		100	12·74	34·84	26·34							
		150	12·34	34·85	26·42							
		200	11·90	34·82	26·49							
		300	10·71	34·74	26·65							
		400	9·41	34·68	26·82							
		600	6·25	34·43	27·09							
		800	5·06	34·51	27·30							
WS 634	24	0	15·11	34·48	25·57	1·16	—	**N 50 V**	100–0	1615	1617	
		10	14·35	34·49	25·73	—	—	**N 70 B**	109–0	1633	1653	KT
		20	13·83	34·69	26·00	2·22	—	**N 100 B**				
		30	13·92	34·72	26·00							
		40	13·59	34·77	26·11	3·14						
		50	13·30	34·81	26·21							
		60	13·15	34·84	26·26	3·14						
		80	13·06	34·84	26·28							
		100	12·83	34·87	26·34	3·25						
		150	12·49	34·85	26·39							
		200	11·85	34·81	26·49	2·97						
		300	10·99	34·75	26·61							
		400	9·70	34·68	26·77	2·22						
		600	6·16	34·43	27·11							
WS 635	24	0	14·90	34·46	25·59	1·20	—	**N 50 V**	100–0	1700	1702	
		10	14·51	34·47	25·69							
		20	13·91	34·58	25·90	1·82						
		30	13·63	34·70	26·04							
		40	13·53	34·73	26·10	2·34						
		50	13·41	34·73	26·12							
		60	13·30	34·77	26·17	2·57						
		80	13·07	34·78	26·23							
		100	12·86	34·81	26·30	2·85						
		150	12·51	34·81	26·37							
		200	12·09	34·83	26·46	2·85						
		300	10·95	34·72	26·58							
		400	9·90	34·62	26·70	2·85						
WS 636	1	0	16·23	34·66	25·45	—	—	**N 70 B**	65–0	**2020**	**2040**	KT
								N 100 B				
								N 100 B	190–65	**2020**	**2048**	Depth estimated
								N 50 V	100–0	**2103**	**2105**	
WS 637	3	0	15·67	34·88	25·75	—	—	**N 50 V**	100–0	**2008**	**2010**	
								N 70 B	88–0	**2034**	**2055**	KT
								N 100 B				
								N 100 B	235–90	**2034**	**2105**	Depth estimated
WS 638	3	0	18·62	35·01	25·15	—	6·06	**N 50 V**	100–0	**0520**	**0522**	
		10	18·62	35·02	25·16	—	—	**N 70 V**	30–0	0700		
		20	18·62	35·03	25·16	—	5·12	,,	100–50			
		30	18·57	35·05	25·18	—	—	,,	250–100			
		40	14·68	34·44	25·63	—	3·97	,,	500–250			
		50	13·61	34·54	25·93	—	—	,,	750–500			
		60	13·34	34·62	26·06	—	1·45	,,	1000–750			
		80	13·14	34·70	26·15	—	—	**N 50 V**	250–100			
		100	13·09	34·82	26·26	—	0·23	,,	100–50			
		150	12·56	34·83	26·37	—	—	,,	30–0	—	0930	
		200	11·91	34·82	26·49	—	0·17	**N 70 B**	101–0	0955	1015	KT
		300	10·60	34·72	26·65	—	—	**N 100 B**				

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 638 *cont.*	18° 54·5′ S, 71° 06′ W	1931 19 vi											
WS 639	18° 44′ S, 70° 48′ W	19 vi	1230	1485 gy.Oz	S	4–6	S	2	o	1016·8	18·3	14·4	low long S swell
WS 640	18° 28′ S, 70° 23·6′ W	19 vi	1744	82 d.gn.M	SE	0–3	SE	2	c	1016·4	16·1	13·9	low long SE swell
WS 641	18° 27·5′ S, 70° 26·5′ W	19 vi	1911	108 br.gn.M	Lt airs	0–3	SE	2	c	1016·2	16·1	14·4	low long SE swell
WS 642	18° 28·4′ S, 70° 32·2′ W	19 vi	2118	146 d.gn.M	Lt airs	0–3	SE	2	c	1018·1	16·1	14·4	low long SE swell
WS 643	18° 30′ S, 70° 42·8′ W	19–20 vi	2323	*ca.* 730	WSW	4–6	WSW	2	c	1016·7	16·1	12·8	low long SW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 638 *cont.*	3	400	8·93	34·63	26·86	—	0·17	**N 100 B**	265–100	0955	1022	Depth estimated
		600	6·49	34·49	27·10							
		800	5·11	34·46	27·25	—	0·48					
		1000	4·28	34·50	27·38							
		1500	2·74	34·60	27·61	—	1·51					
		2000	2·25	34·63	27·68							
WS 639	3	0	18·62	34·98	25·13	—	—	**N 50 V**	100–0	1334	1336	
		10	18·60	35·00	25·14	—	—	**N 70 B**	76–0	1358	1419	KT
		20	18·59	34·99	25·14	—	—	**N 100 B**				
		30	16·72	34·67	25·35	—	—	**N 100 B**	210–75	1358	1424	Depth estimated
		40	14·88	34·79	25·86							
		50	14·54	34·88	26·00							
		60	14·14	34·88	26·08							
		80	13·81	34·88	26·15							
		100	13·39	34·87	26·23							
		150	12·56	34·89	26·41							
		200	12·10	34·85	26·47							
		300	11·10	34·75	26·59							
		400	9·39	34·65	26·80							
		600	6·17	34·51	27·16							
		800	5·35	34·50	27·26							
		1000	4·05	34·60	27·48							
		1300	3·24	34·49	27·47							
WS 640	4	0	16·57	34·70	25·41	—	—	**N 50 V**	80–0	**1823**	**1825**	
		10	15·01	34·60	25·68	—	—	**N 70 B**	50–0	**1835**	**1856**	KT
		20	13·56	34·51	25·92	—	—	**N 100 B**				
		30	13·84	34·87	26·14							
		40	13·52	34·88	26·21							
		50	13·40	34·88	26·24							
		60	13·21	34·86	26·26							
		70	12·94	34·88	26·32							
WS 641	4	0	17·62	34·85	25·26	—	5·14	**N 50 V**	100–0	**1916**	**1918**	
		10	17·21	34·80	25·33	—	—	**N 70 B**	92–0	**2020**	**2040**	KT
		20	14·64	34·63	25·78	—	3·56	**N 100 B**				
		30	13·91	34·74	26·03							
		40	13·91	34·88	26·13							
		50	13·63	34·88	26·19							
		60	13·41	34·88	26·23							
		80	12·88	34·84	26·31							
		100	12·84	34·83	26·31	—	0·10					
WS 642	4	0	17·91	35·04	25·34	—	—	**N 50 V**	100–0	**2143**	**2145**	
		10	17·88	34·92	25·26	—	—	**N 70 B**	82–0	**2159**	**2219**	KT
		20	14·76	34·61	25·74	—	—	**N 100 B**				
		30	14·36	34·88	26·04	—	—	**N 100 B**	195–70	2159	2223	Depth estimated
		40	14·08	34·86	26·08							
		50	13·85	34·91	26·17							
		60	13·62	34·91	26·22							
		80	13·25	34·90	26·29							
		100	13·22	34·88	26·27							
		135	12·61	34·85	26·37							
WS 643	4	0	18·12	34·95	25·23	—	5·24	**N 50 V**	100–0	**2324**	**2326**	
		10	18·06	34·92	25·21	—	—	**N 70 B**	76–0	**0034**	**0056**	KT
		20	18·04	34·90	25·21	—	5·19	**N 100 B**				
		30	16·49	34·70	25·43	—	—	**N 100 B**	210–75	**0034**	**0107**	Depth estimated
		40	15·49	34·75	25·69	—	2·54					
		50	14·21	34·83	26·03							
		60	13·83	34·88	26·15	—	2·20					
		80	13·33	34·84	26·22							
		100	13·16	34·90	26·30	—	0·07					
		150	12·63	34·88	26·39							
		200	12·21	34·88	26·47	—	0·30					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 643 *cont.*	18° 30′ S, 70° 42·8′ W	1931 19–20 vi											
WS 644	16° 55·2′ S, 72° 39′ W	20 vi	2000	—	S	7–10	S	2	bc	1016·9	15·0	13·3	low long SSW swell
WS 645	15° 42·3′ S, 75° 03′ W	21 vi	2000	—	S	7–10	S	3	b	1014·9	15·6	13·9	mod. av. SSE swell
WS 646	15° 35′ S, 75° 41′ W	22 vi	0400	3147 h	SE	11–16	SE	4	bc	1015·1	15·6	14·4	mod. av. SE swell
WS 647	15° 19·2′ S, 75° 11·5′ W	22 vi	1152	66 gy.S.M	SE	22–33	SE	4–5	bc	1015·5	16·1	14·2	mod. av. SE swell
WS 648	15° 19·5′ S, 75° 13′ W	22 vi	1305	111 gn.M.S	ESE	17–21	SE	4–5	b	1015·6	15·6	13·3	mod. av. SE swell
WS 649	15° 20′ S, 75° 16·5′ W	22 vi	1448	137 gn.M.S	ESE	11–21	SE	4–5	b	1015·9	15·0	13·3	mod. av. ESE swell
WS 650	15° 22·5′ S, 75° 22′ W	22 vi	1627	143 d.G.S	SE	7–16	SE	3	b	1016·6	14·4	14·0	mod. short SE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	TIME To	Remarks
WS 643 *cont.*	4	300	11·09	34·78	26·61							
		400	9·44	34·64	26·79	—	0·32					
		600	6·39	34·46	27·10							
WS 644	5	0	16·43	34·90	25·59	—	—	**N 50 V**	100–0	**2010**	**2012**	
								N 70 B	84–0	**2031**	**2052**	KT
								N 100 B				
								N 100 B	225–85	**2031**	**2102**	Depth estimated
WS 645	6	0	14·85	34·90	25·95	—	—	**N 50 V**	100–0	**2028**	**2030**	
								N 70 B	67–0	**2050**	**2110**	KT
								N 100 B				
								N 100 B	190–65	**2050**	**2116**	
WS 646	6	0	14·81	34·97	26·01	1·77	3·87	**N 50 V**	100–0	**0540**	**0542**	
		10	14·81	34·97	26·01	—	—	**N 70 V**	50–0	**0550**		
		20	14·81	34·95	26·00	1·50	3·88	,,	100–50			
		30	14·81	34·95	26·00	—	—	,,	250–100			
		40	14·61	34·96	26·04	1·50	3·24	,,	500–250			
		50	14·22	35·03	26·18	—	—	,,	750–500			
		60	14·01	34·94	26·16	1·50	0·91	,,	1000–750	—	0730	
		80	13·72	34·89	26·18	—	—	**N 70 B**	118–0	0749	0809	KT
		100	13·50	34·96	26·27	1·56	0·12	**N 100 B**				
		150	13·24	34·96	26·33	—	—	**N 100 B**	320–120	0749	0822	Depth estimated
		200	12·87	34·91	26·37	1·63	0·11					
		300	11·60	34·82	26·55							
		400	9·61	34·69	26·79	1·77	0·15					
		600	6·63	34·53	27·12							
		800	5·56	34·52	27·25	2·05	0·71					
		1000	4·74	34·52	27·35							
		1500	3·13	34·62	27·60	1·50	1·48					
		2000	2·36	34·63	27·67							
		2500	1·99	34·63	27·70	1·75						
WS 647	6	0	13·79	34·99	26·24	1·77	—	**N 50 V**	100–0	1218	1220	
		10	13·79	34·98	26·24	2·05	—	**N 70 B**	40–0	1230	1251	KT
		20	13·73	34·99	26·26	1·90	—	**N 100 B**				
		30	13·71	34·96	26·23	1·56						
		40	13·61	34·97	26·26	1·90						
		50	13·58	34·97	26·27	1·35						
		60	13·52	34·98	26·30	1·35						
WS 648	6	0	13·82	34·97	26·22	1·77	1·37	**N 50 V**	100–0	1313	1315	
		10	13·84	35·00	26·24	1·77	—	**N 70 B**	109–0	1409	1429	KT. **N 100 B** fouled bottom
		20	13·81	34·99	26·24	2·15	1·65	**N 100 B**				
		30	13·81	34·98	26·24	1·90						
		40	13·67	34·97	26·25	2·15	0·47					
		50	13·59	35·06	26·33	1·39						
		60	13·57	34·97	26·27	2·24	0·11					
		80	13·42	34·93	26·27	1·90						
		100	13·24	34·97	26·34	1·77	0·18					
WS 649	7	0	14·19	35·00	26·17	2·15	—	**N 50 V**	100–0	1524	1526	
		10	14·19	34·97	26·15	2·24	—	**N 70 B**	84–0	1537	1600	KT
		20	14·01	34·99	26·20	2·24	—	**N 100 B**				
		30	13·93	34·98	26·21	1·50						
		40	13·86	35·00	26·24	1·50						
		50	13·80	34·99	26·24	1·90						
		60	13·63	34·99	26·28	1·90						
		80	13·61	34·99	26·28	2·15						
		100	13·51	35·00	26·31	2·24						
WS 650	7	0	14·43	34·99	26·11	2·41	2·77	**N 50 V**	100–0	1634	1636	
		10	14·42	34·99	26·11	2·22	—	**N 70 B**	118–0	1734	**1752**	KT
		20	14·28	34·98	26·14	2·32	2·77	**N 100 B**	100–0	**1810**	**1830**	Depth estimated
		30	14·16	35·00	26·17	2·32						

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 650 *cont.*	15° 22·5′ S, 75° 22′ W	1931 22 vi											
WS 651	15° 31′ S, 75° 37·5′ W	22 vi	1930	1266 d.M	SE	7–16	SE	3	b	1016·7	13·9	12·8	mod. short SE swell
WS 652	16° 21·5′ S, 76° 30·2′ W	23 vi	0645	3987 br.gy.M	SE	17–21	SE	4	o	1017·9	16·7	15·0	mod. av. S swell
WS 653	16° 54′ S, 77° 13′ W	23 vi	1705	—	SE	17–21	SE	4	c	1017·4	17·9	15·6	mod. av. SE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 650 *cont.*	7	40	13.97	34.99	26.21	2.32	0.69					
		50	13.82	35.03	26.26	2.41						
		60	13.74	35.20	26.42	2.66	0.37					
		80	13.57	35.01	26.31	2.32						
		100	13.31	34.99	26.34	2.32	0.13					
		140	13.13	34.99	26.38	2.97						
WS 651	7	0	14.86	35.01	26.03	1.90	—	**N 50 V**	100–0	**2123**	**2125**	
		10	14.86	34.99	26.02	2.22	—	**N 70 B**	80–0	**2144**	**2205**	KT
		20	14.83	35.00	26.03	2.22	—	**N 100 B**				
		30	14.73	35.02	26.07	2.22	—	**N 100 B**	220–80	**2144**	**2214**	Depth estimated
		40	14.63	35.02	26.09	1.90						
		50	14.27	35.00	26.15	1.90						
		60	14.26	35.02	26.17	2.22						
		80	13.60	34.97	26.27	2.32						
		100	13.50	34.99	26.30	2.53						
		150	13.03	34.98	26.40	2.53						
		200	12.49	34.91	26.45	2.41						
		300	11.20	34.86	26.65	2.32						
		400	9.13	34.70	26.88	2.53						
		600	6.75	34.59	27.16	2.79						
		800	5.24	34.54	27.31	2.79						
		1000	4.49	34.58	27.42	2.79						
WS 652	7	0	18.82	35.22	25.26	0.13	5.05	**NH**	0	0800		
		10	18.82	35.26	25.28	—	—	**N 50 V**	60–0	0930		
		20	18.82	35.24	25.27	0.27	4.88	,,	80–60			
		30	18.82	35.26	25.28	—	—	,,	140–80	—	0950	
		40	18.82	35.26	25.29	0.55	4.93	**N 70 B**	102–0	1053	1113	KT
		50	18.80	35.28	25.30	—	—	**N 100 B**				
		60	18.07	35.10	25.35	0.55	4.67	**N 100 B**	270–100	1053	1118	Depth estimated
		80	14.15	34.53	25.81							
		100	13.81	34.66	25.98	1.35	2.90					
		150	12.89	34.91	26.37							
		200	12.18	34.90	26.50	2.22	0.21					
		300	11.17	34.87	26.66							
		400	9.80	34.75	26.82	2.22	0.30					
		600	7.89	34.64	27.03	—	—	—	—	—	—	Very heavy stray on water bottle wire
		800	7.41	34.63	27.09	2.66	0.68	—	—	—	—	
		1000	6.90	34.59	27.13	—	—	—	—	—	—	
		1500	5.13	34.59	27.36	2.41	0.46	—	—	—	—	
		2000	3.88	34.55	27.47	—	—	—	—	—	—	
		2500	3.72	34.61	27.52	2.13	1.09	—	—	—	—	
		3000	3.06	34.59	27.58	—	—	—	—	—	—	
		3500	2.60	34.67	27.68	2.05	1.15	—	—	—	—	
WS 653	8	0	18.79	35.19	25.24	0.13	5.68	**N 50 V**	100–0	**1833**	**1835**	
		10	18.80	35.21	25.25	—	—	**N 70 V**	50–0	**1850**		
		20	18.77	35.20	25.25	0.21	4.17	,,	100–50			
		30	18.74	35.20	25.26	—	—	,,	250–100			
		40	18.72	35.19	25.25	0.40	4.78	,,	500–250			
		50	15.11	34.72	25.75	—	—	,,	1000–750			
		60	14.26	34.66	25.88	1.35	1.93	,,	750–500	—	**2030**	
		80	13.27	34.67	26.10	—	—	**N 70 B**	118–0	**2120**	**2141**	KT
		100	12.62	34.63	26.20	1.63	1.35	**N 100 B**				
		150	12.31	34.84	26.43	—	—	**N 100 B**	320–120	**2120**	**2150**	Depth estimated
		200	11.54	34.78	26.52	1.63	1.46					
		300	10.03	34.70	26.74							
		400	8.33	34.58	26.92	1.82	0.27					
		600	6.11	34.50	27.16							
		800	4.94	34.49	27.29	1.82	0.32					
		1000	4.15	34.51	27.40							
		1500	2.80	34.57	27.58	1.90	1.16					
		2000	2.31	34.50	27.56							
		2500	1.85	34.64	27.72	1.90	3.20					
		3000	1.76	34.66	27.74							

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 654	16° 36′ S, 76° 55·5′ W	1931 24 vi	0014	—	ESE	11–21	SE	4–5	c	1017·0	18·3	15·4	mod. av. to mod. long SE swell
WS 655	16° 08′ S, 76° 22′ W	24 vi	0815	3316 br.gy.M	ESE	11–16	ESE	4	o	1018·8	16·7	14·4	mod. av. ESE swell
WS 656	15° 52·5′ S, 76° 07·5′ W	24 vi	1357	—	SE	11–16	SE	4	c	1017·9	16·7	14·4	mod. short to mod. av. SE swell
WS 657 A	15° 44′ S, 75° 59′ W	24 vi	1737	—	SE	11–16	SE	3	c	1017·1	15·8	15·6	mod. av. SE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 654	8	0	19·23	35·30	25·21	—	—	**N 50 V**	100–0	**0133**	**0135**	
		10	19·20	35·29	25·21	—	—	**N 70 B**	87–0	**0216**	**0235**	KT
		20	19·24	35·32	25·22	—	—	**N 100 B**				
		30	19·23	35·29	25·20	—	—	**N 100 B**	230–85	**0216**	**0241**	Depth estimated
		40	19·23	35·29	25·20							
		50	19·23	35·34	25·24							
		60	19·24	35·30	25·21							
		80	16·40	34·79	25·52							
		100	13·96	34·50	25·82							
		150	11·98	34·69	26·36							
		200	11·40	34·77	26·54							
		300	10·00	34·71	26·75							
		400	8·50	34·62	26·93							
		600	6·37	34·51	27·14							
		800	5·13	34·50	27·28							
		1000	4·74	34·50	27·33							
		1500	2·93	34·58	27·58							
		2000	2·23	34·62	27·68							
		2500	1·87	34·65	27·72							
		3000	2·03	34·62	27·70							
WS 655	8	0	17·26	35·03	25·49	0·82	—	**N 50 V**	100–0	1030	1032	
		10	17·26	35·01	25·48	—	—	**N 70 B**	84–0	1125	1145	KT
		20	17·12	35·01	25·52	0·82	—	**N 100 B**				
		30	15·07	35·08	26·03	—	—	**N 100 B**	225–85	1125	1155	Depth estimated
		40	14·70	35·05	26·09	1·69						
		50	14·55	35·03	26·11							
		60	14·25	35·03	26·17	2·05						
		80	13·51	34·93	26·25							
		100	13·09	34·92	26·33	2·47						
		150	12·41	34·91	26·46							
		200	11·80	34·88	26·55	2·24						
		300	10·56	34·77	26·69							
		400	8·79	34·67	26·91	2·36						
		600	6·69	34·57	27·14							
		800	5·34	34·57	27·31	2·74						
		1000	4·40	34·62	27·47							
		1500	3·05	34·58	27·57	3·29						
		2000	2·34	34·64	27·68							
		2500	1·92	34·66	27·72	3·10						
		3000	1·82	34·91	27·94							
WS 656	9	0	16·24	34·90	25·64	1·41	4·91	**N 50 V**	100–0	1542	1544	
		10	16·21	35·02	25·74	—	—	**N 70 B**	80–0	1600	1619	KT
		20	15·90	34·93	25·74	1·41	4·29	**N 100 B**				
		30	15·61	34·88	25·76	—	—	**N 100 B**	220–80	1600	1631	Depth estimated
		40	14·15	34·72	25·96	1·50	2·64					
		50	14·28	34·79	25·99							
		60	14·49	34·89	26·02	1·56	1·16					
		80	14·17	34·94	26·12							
		100	13·30	34·88	26·26	2·05	0·34					
		150	12·71	34·93	26·41							
		200	12·11	34·90	26·51	2·22	0·16					
		300	10·68	34·81	26·71							
		400	9·43	34·73	26·86	2·41	0·14					
		600	6·78	34·58	27·14							
		800	5·40	34·53	27·28	3·33	0·75					
		1000	4·37	34·56	27·42							
		1500	3·14	34·63	27·60	3·33	1·61					
		2000	2·39	34·64	27·68							
		2500	2·09	34·70	27·74	2·53	2·13					
		3000	1·93	34·67	27·73							
WS 657 A	9	—	—	—	—	—	—	**N 70 H**	0	**1740**	**1750**	Position A
								N 100 H	0–5			

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 657 B	15° 38·3′ S, 75° 53·4′ W	1931 24 vi	1850	—	SE	11–16	SE	3	c	1017·1	15·8	15·6	mod. av. SE swell
WS 658	13° 45·5′ S, 76° 20′ W	25 vi	1220	—	S	7–10	S	2	bc	1014·5	16·7	14·4	low long S swell
WS 659	13° 37·8′ S, 76° 20′ W	25 vi	2115	71 d.gn.M	NW × N	7–10	NW × N	2	b	1016·7	16·1	15·2	low long NNW swell
WS 660	12° 23·5′ S, 77° 11·2′ W	26 vi	0936	—	SW	4–6	SW	1–2	or	1015·6	15·6	15·0	low long SW swell
WS 661	12° 08′ S, 77° 16′ W	26 vi	1153	—	SW	4–6	S	2	c	1014·9	17·2	15·6	mod. short S swell
	12° 08·5′ S, 77° 16′ W		1354	—	SW	4–6	S	2	c	1013·9	17·2	15·6	mod. short S swell
WS 662	12° 09·5′ S, 77° 15′ W	26 vi	1245	—	SW	4–10	SW	2	c	1015·5	17·2	15·6	mod. short S swell
WS 663	12° 09·6′ S, 77° 15′ W	1 vii	1134	62 d.gn.M	ESE	1–6	ESE	1–2	c	1013·8	17·6	15·5	mod. short S swell
WS 664	12° 11·5′ S, 77° 17′ W	1 vii	1325	101 gy.M	SE	7–10	SSE	3–4	c	1013·0	16·1	15·0	mod. av. SE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 657 B	9	0	15·36	34·96	25·88	2·34	—	**N 50 V**	100–0	**2013**	**2015**	Position B
		10	15·31	34·97	25·90	—	—	**N 70 B**	67–0	**2120**	**2139**	KT
		20	15·11	34·97	25·94	2·15	—	**N 100 B**				
		30	15·06	35·02	26·00	—	—	**N 100 B**	190–65	**2120**	**2149**	Depth estimated
		40	15·00	34·98	25·98	2·34						
		50	14·77	35·00	26·04							
		60	14·62	34·99	26·07	2·34						
		80	14·26	35·11	26·24							
		100	13·51	35·03	26·33	2·34						
		150	13·01	34·98	26·40							
		200	12·16	34·92	26·51	2·45						
		300	10·91	34·79	26·65							
		400	9·08	34·69	26·88	2·85						
		600	6·53	34·53	27·14							
		800	5·62	34·53	27·25	3·02						
		1000	4·61	34·54	27·38							
		1500	3·11	34·57	27·55	2·85						
		2000	2·34	34·62	27·67							
		2500	1·96	34·62	27·70	2·57						
		3000	1·71	34·65	27·73							
WS 658	10	0	19·10	—	—	—	—	**N 50 V**	15–0	1228	1230	
WS 659	10	0	17·60	35·16	25·51	—	—	**N 50 V**	50–0	**2120**	**2122**	
								N 70 B	54–0	**2145**	**2205**	KT
								N 100 B				
WS 660	10	—	—	—	—	—	—	**N 50 H**	0	0935	0940	
								N 70 H				
								N 50 V	100–0	0953	0955	
								N 70 B	105–0	1005	1025	KT
								N 100 B				
WS 661	10	0	16·61	35·07	25·67	—	—	**N 50 V**	60–0	1230	1232	
		10	15·91	35·06	25·83	—	—	**N 100 H**	0–5	1355	1415	
	10	20	15·56	35·07	25·92	—	—	**N 70 H**	0–5	1400	1420	
		30	15·42	35·05	25·93							
		40	15·42	35·08	25·96							
		50	15·42	35·07	25·95							
		60	15·40	35·06	25·94							
WS 662	10	0	16·86	34·99	25·56	—	—	**N 50 V**	50–0	1315	1317	
		10	16·19	35·00	25·72	—	—	**N 70 H**	0–5	1320	1340	
		20	16·08	35·04	25·78	—	—	**N 100 H**				
		30	15·97	35·06	25·81							
		40	15·50	35·06	25·92							
		50	15·36	35·05	25·94							
		60	15·27	35·06	25·97							
WS 663	15	0	17·20	35·08	25·54	—	—	**N 70 V**	25–0	1205		
		10	16·87	35·10	25·64	—	—	,,	50–23	—	1215	
		20	16·75	35·17	25·73	—	—	**N 50 V**	50–25	1230		
		30	16·39	35·09	25·75	—	—	,,	25–0	—	1240	
		40	15·90	35·08	25·85	—	—	**N 70 B**	44–0	1250	1313	KT
		50	15·57	35·08	25·92	—	—	**N 100 B**				
								N 50 H	0–5	1254	1256	
WS 664	16	0	17·20	35·12	25·57	—	4·41	**N 50 V**	25–0	1403		
		10	16·96	35·15	25·66	—	—	,,	50–25			
		20	16·78	35·14	25·69	—	2·76	,,	95–50			
		30	16·27	35·13	25·80	—	—	**N 70 V**	25–0			
		40	15·64	35·07	25·90	—	1·18	,,	50–25			
		50	15·49	35·08	25·94	—	—	,,	95–50	—	1434	
		60	14·92	35·07	26·06	—	0·37	**N 70 B**	100–0	1445	1505	KT
		80	14·71	35·06	26·10	—	—	**N 100 B**	90–0	1528	1551	Depth estimated
		95	14·66	35·05	26·10	—	0·26					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 665	12° 13·3′ S, 77° 21·8′ W	1931 1 vii	1613	134 d.gn.M	S	11–16	S	3	o	1012·6	15·6	15·0	mod. short S swell
WS 666	12° 18·5′ S, 77° 30·5′ W	1 vii	1834	199 d.gn.M	SE	7–10	SE	2–3	o	1013·2	15·6	14·7	mod. short SE swell
WS 667	12° 23·2′ S, 77° 39·5′ W	1 vii	2058	474 bl.G	SE	11–16	SE	3	o	1013·2	16·1	15·3	mod. short SE swell
WS 668	12° 48·5′ S, 78° 45·8′ W	2 vii	0737	5101	SE × E	11–16	SE	3	c	1015·4	16·7	15·1	mod. av. SE swell
WS 669	12° 33·5′ S, 78° 21·6′ W	2 vii	1454	3840 gy.M	SE	17–21	SE	4	c	1013·3	16·9	15·0	mod. av. SE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom $m.^3$	O_2 c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 665	16	0	17·55	35·20	25·56	—	—	**N 50 V**	100–0	1653	1655	
		10	17·53	35·21	25·57	—	—	**N 70 B**	101–0	1705	1728	KT
		20	17·51	35·24	25·60	—	—	**N 100 B**				
		30	15·91	35·10	25·87							
		40	15·34	35·08	25·98							
		50	15·03	35·08	26·04							
		60	14·78	35·05	26·07							
		80	14·52	35·19	26·24							
		100	14·41	35·06	26·16							
		130	14·34	35·03	26·15							
WS 666	16	0	17·83	35·25	25·52	—	3·98	**N 50 V**	100–0	1836	1838	
		10	17·83	35·26	25·52	—	—	**N 70 B**	89–0	1935	1958	KT
		20	17·82	35·26	25·53	—	4·02	**N 100 B**				
		30	17·62	35·21	25·55							
		40	17·16	35·17	25·62	—	2·48					
		50	16·61	35·13	25·72							
		60	15·39	35·07	25·95	—	1·00					
		80	14·51	35·06	26·14							
		100	14·49	35·08	26·16	—	0·23					
		150	14·04	35·05	26·23							
WS 667	16	0	19·13	35·49	25·38	—	—	**N 50 V**	100–0	2135	2137	
		10	19·13	35·48	25·37	—	—	**N 70 B**	100–0	2212	2232	Depth estimated
		20	19·14	35·51	25·39	—	—	**N 100 B**				
		30	19·14	—	—	—	—	**N 100 B**	320–100	2310	2340	Depth estimated
		40	19·13	35·48	25·37							
		50	17·01	35·18	25·68							
		60	15·53	35·07	25·92							
		80	15·09	35·07	26·02							
		100	14·18	35·00	26·17							
		150	13·71	34·99	26·26							
		200	12·98	34·91	26·35							
		300	11·95	34·90	26·54							
		400	10·67	34·81	26·71							
WS 668	16	0	18·88	35·40	25·38	—	5·21	**N 50 V**	100–0	0910	0912	
		10	18·87	35·44	25·41	—	—	**N 70 B**	116–0	1136	1157	KT
		20	18·90	35·45	25·41	—	4·88	**N 100 B**				
		30	18·91	35·49	25·43	—	—	**N 100 B**	315–115	1136	1202	Depth estimated
		40	16·91	35·06	25·60	—	3·63					
		50	16·51	34·99	25·64							
		60	15·51	34·97	25·85	—	0·93					
		80	14·49	34·96	26·07							
		100	13·84	34·95	26·20	—	0·12					
		150	12·94	34·94	26·38							
		200	12·29	34·87	26·45	—	0·17					
		300	11·12	34·87	26·67							
		400	9·49	34·74	26·86	—	0·75					
		600	7·06	34·59	27·11							
		800	5·48	34·55	27·29	—	0·85					
		1000	4·76	34·61	27·42							
		1500	3·09	34·70	27·66	—	1·79					
		2000	2·38	34·67	27·70							
		2500	1·97	34·69	27·74	—	0·12					
		3000	1·87	34·52	27·62							
		3500	1·78	34·59	27·69	—	1·86					
		4000	1·72	34·64	27·73							
WS 669	16	0	17·21	35·18	25·63	—	—	**N 50 V**	100–0	1555	1557	
		10	17·20	35·17	25·61	—	—	**N 70 B**	91–0	1824	1844	KT
		20	17·20	35·18	25·63	—	—	**N 100 B**				
		30	16·96	35·14	25·65	—	—	**N 100 B**	240–90	1824	1850	Depth estimated
		40	16·89	35·12	25·65							
		50	16·81	35·14	25·69							
		60	16·77	35·11	25·68							

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 669 *cont.*	12° 33·5′ S, 78° 21·6′ W	1931 2 vii											
WS 670	12° 22·2′ S, 78° 13·8′ W	2 vii	2011	—	SE	11–16	SE	4	o	1015·0	16·7	15·0	mod. av. SE swell
WS 671	12° 10·8′ S, 77° 59·2′ W	3 vii	0000	1920 gn.M	SE	11–16	SE	4	o	1014·7	17·2	16·3	mod. av. SE swell
WS 672	12° 09·7′ S, 77° 14′ W	8 vii	0800	—	SSE	7–10	SSE	3	o	1013·4	15·6	15·0	mod. av. S swell
WS 673	11° 23·6′ S, 77° 38′ W	8 vii	2012	—	SSE	7–10	SE	2	c	1012·0	16·1	15·3	mod. short SE swell
WS 674	09° 00′ S, 79° 40′ W	9 vii	1915	113	ESE	7–10	SSW	4	o	1011·5	19·4	16·7	mod. short ESE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 669 *cont.*	16	80	14·18	34·97	26·15							
		100	13·72	35·08	26·32							
		150	13·03	34·93	26·35							
		200	12·39	34·88	26·44							
		300	11·11	34·83	26·64							
		400	9·45	34·65	26·79							
		600	8·45	34·66	26·96	—	—	—	—	—	—	
		800	6·46	34·53	27·14	—	—	—	—	—	—	
		1000	5·23	34·50	27·27	—	—	—	—	—	—	
		1500	3·57	34·54	27·49	—	—	—	—	—	—	Very heavy stray on water-bottle wire
		2000	3·33	34·53	27·50	—	—	—	—	—	—	
		2500	2·51	34·57	27·61	—	—	—	—	—	—	
		3000	2·16	34·62	27·69	—	—	—	—	—	—	
WS 670	17	0	19·21	35·41	25·30	—	4·89	**N 50 V**	100–0	**2148**	**2150**	
		10	19·22	35·45	25·32	—	—	**N 70 B**	109–0	**2212**	**2235**	KT
		20	19·21	35·50	25·36	—	4·86	**N 100 B**				
		30	19·20	35·47	25·35	—	—	**N 100 B**	235–90	**2212**	**2240**	Depth estimated
		40	17·29	35·16	25·58	—	3·10					
		50	15·45	34·97	25·86							
		60	14·89	34·92	25·95	—	0·96					
		80	14·01	34·92	26·14							
		100	13·50	34·96	26·27							
		150	12·61	34·91	26·42							
		200	12·15	34·89	26·49	—	0·16					
		300	10·92	34·79	26·65							
		400	9·68	34·70	26·80	—	0·15					
		600	7·23	34·58	27·08							
		800	5·82	34·56	27·25	—	0·53					
		1000	5·32	34·52	27·28	—	—	—	—	—	—	
		1500	3·63	34·58	27·51	—	1·69	—	—	—	—	Heavy stray on water-bottle wire
		2000	2·64	34·61	27·63	—	—	—	—	—	—	
		2500	2·25	34·62	27·68	—	2·22	—	—	—	—	
WS 671	17	0	19·33	35·45	25·30	—	—	**N 50 V**	100–0	**0113**	**0115**	
		10	19·33	—	—	—	—	**N 70 B**	89–0	**0257**	**0317**	KT
		20	19·31	35·59	25·41	—	—	**N 100 B**				
		30	19·33	35·46	25·31	—	—	**N 100 B**	235–90	**0257**	**0325**	Depth estimated
		40	19·13	35·41	25·32							
		50	18·75	35·40	25·41							
		60	16·27	34·98	25·70							
		80	14·25	34·90	26·08							
		100	13·81	34·97	26·23							
		150	12·92	34·97	26·40							
		200	12·22	34·93	26·51							
		300	11·25	34·90	26·67							
		400	9·20	34·70	26·87							
		600	6·66	34·60	27·17							
		800	6·20	34·60	27·23							
		1000	5·00	34·62	27·40							
		1500	3·30	34·61	27·58							
WS 672	22	0	17·34	35·14	25·56	—	—	**N 50 V**	45–0	0828	0829	
		10	17·21	35·10	25·56							
		20	17·10	35·14	25·62							
		30	16·96	35·13	25·64							
		40	16·21	35·08	25·78							
		45	15·51	35·05	25·91							
WS 673	23	0	17·32	35·18	25·60	—	—	**N 50 V**	95–0	**2020**	**2022**	
								N 70 B	47–0	**2039**	**2059**	KT
								N 100 B				
WS 674	24	0	20·36	35·48	25·05	1·03	4·88	**N 50 V**	100–0	**2028**	**2030**	
		10	20·34	35·42	25·01	1·08	—	**N 70 V**	50–0	**2035**		
		20	20·26	35·48	25·07	1·29	4·69	,,	100–50	—	**2045**	

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 674 *cont.*	09° 00′ S, 79° 40′ W	1931 9 vii											
WS 675	08° 14·5′ S, 78° 58′ W Salaverry Roads	10 vii	1305	10	SW	1–3	S	1	b	1012·8	18·9	17·2	low long SW swell
WS 676	08° 17′ S, 79° 01·5′ W	10 vii	1413	29 bl.M	SSW	4–6	S	2	b	1011·0	20·0	17·8	low long S swell
WS 677	08° 19·5′ S, 79° 05·8′ W	10 vii	1525	49 gn.M. Sh	SSW	4–6	S	2	b	1010·7	19·3	18·2	low long S swell
WS 678	08° 35·5′ S, 78° 57′ W	10 vii	1824	55 gn.M. Sh	SW	1–3	S×W	0	b	1012·0	17·8	17·2	mod. short S swell
WS 679	08° 38′ S, 79° 01·5′ W	10 vii	2000	66	SSW	4–6	S	2	b	1012·0	17·8	17·2	mod. av. S swell
WS 680	08° 44′ S, 79° 15′ W	10 vii	2238	91 d.gn.M	SW	1–3	S×W	1	bc	1012·1	17·8	17·2	low long S swell
WS 681	08° 49′ S, 79° 24′ W	11 vii	0100	106 R	SE	4–6	S	1	bc	1013·0	18·9	18·3	low long S swell
WS 682	08° 53′ S, 79° 33′ W	11 vii	0320	110 br.S.Sh	SE	4–6	S	1	bc	1012·8	19·1	18·3	low long S swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 674 *cont.*	24	30	20·23	35·41	25·03	1·33	—	**N 100 B**	59–0	**2050**	**2116**	KT
		40	18·86	35·25	25·26	1·50	2·90	**N 70 B**	85–0	**2126**	**2146**	KT
		50	17·31	35·14	25·57	1·77						
		60	16·70	35·15	25·72	2·24	1·34					
		80	16·01	35·13	25·86	1·90						
		100	15·11	35·08	26·03	1·90	0·60					
WS 675	24	0	16·00	35·11	25·86	—	—	**N 70 H**	0–5	1321	1341	
		10	15·67	35·05	25·87	—	—	**N 100 H**				
								N 50 H	0–5	1329	1331	
WS 676	25	0	16·71	35·08	25·66	2·13	1·86	**N 50 H**	0–5	1436	1438	
		10	16·09	35·05	25·78	2·32	—	**N 70 B**	0–10	1436	1456	
		20	15·60	35·05	25·89	2·32	1·64	**N 100 B**				
		25	15·55	35·07	25·92							
WS 677	25	0	16·83	35·09	25·64	2·40	—	**N 50 V**	45–0	1545	1546	
		10	16·59	35·06	25·67	2·40	—	**N 70 B**	36–0	1600	1620	KT
		20	16·34	35·06	25·73	2·40	—	**N 100 B**				
		30	15·81	35·08	25·87	2·53						
		40	15·43	35·09	25·96	2·85						
		45	15·42	—	—	—	—	—	—	—	—	Water bottle struck bottom
WS 678	25	0	16·86	35·08	25·63	1·98	3·71	**N 50 V**	45–0	**1828**	**1830**	
		10	16·20	35·05	25·75	1·90	—	**N 70 B**	32–0	**1909**	**1931**	KT
		20	15·72	35·07	25·88	1·98	0·63	**N 100 B**				
		30	15·46	35·08	25·95	2·41						
		40	15·45	35·08	25·95	2·79	0·14					
		48	15·45	—	—	—	—	—	—	—	—	Water bottle struck bottom
WS 679	25	0	17·40	35·08	25·50	1·29	—	**N 50 V**	50–0	**2034**	**2035**	
		10	16·49	35·08	25·71	1·82	—	**N 70 B**	50–0	**2044**	**2105**	Depth estimated
		20	16·10	35·10	25·82	1·90	—	**N 100 B**				
		30	15·57	35·08	25·92	2·15						
		40	15·30	35·10	26·00	2·45						
		50	15·27	35·10	26·01	2·45						
		60	15·24	35·26	26·13	2·15						
WS 680	25	0	17·41	35·16	25·55	0·95	3·54	**N 50 V**	90–0	**2316**	**2318**	
		10	17·01	35·17	25·66	0·95	—	**N 70 B**	50–0	**2330**	**2350**	KT
		20	16·70	35·15	25·72	1·35	2·72	**N 100 B**				
		30	16·61	35·13	25·72	1·50						
		40	16·20	35·11	25·81	1·35	1·06					
		50	15·95	35·11	25·87	1·35						
		60	15·14	35·10	26·04	1·35	0·18					
		80	14·99	35·08	26·05	1·35						
WS 681	25	0	19·44	35·36	25·20	—	—	**N 50 V**	100–0	**0146**	**0148**	
		10	18·64	35·30	25·36	0·40	—	**N 70 B**	73–0	**0158**	**0217**	KT
		20	18·02	35·25	25·47	0·82	—	**N 100 B**				
		30	17·31	35·18	25·61	1·08						
		40	16·70	35·12	25·69	1·08						
		50	16·30	35·12	25·79	1·50						
		60	15·30	35·09	25·99	1·62						
		80	15·08	35·07	26·02	1·62						
		100	15·08	35·09	26·04	1·75						
WS 682	25	0	20·04	35·42	25·09	0·13	—	**N 50 V**	100–0	**0405**	**0407**	
		10	20·04	35·42	25·09	0·27	—	**N 70 B**	102–0	**0418**	**0438**	KT
		20	19·92	35·41	25·12	0·27	—	**N 100 B**				
		30	19·10	35·33	25·26	0·27						
		40	17·58	35·17	25·52	0·95						
		50	16·54	35·12	25·73	1·22						
		60	15·72	35·10	25·91	1·56						
		80	15·66	35·09	25·91	1·63						
		100	15·00	35·08	26·05	1·69						

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 683	10° 37′ S, 78° 17·3′ W	1931 11 vii	2000	—	SE × S	7–16	SE × S	3	o	1013·1	18·9	17·2	mod. av. SE swell
WS 684	12° 09·5′ S, 77° 15′ W	12 vii	1018	—	SSE	7–10	S	2	o	1015·0	16·1	15·6	low long S swell
WS 685	12° 09·5′ S, 77° 15′ W	15 vii	1721	—	S × E	7–10	S × E	2	o	1013·7	17·1	15·6	mod. long S swell
WS 686	09° 25·5′ S, 80° 22′ W	17 vii	0036	4228 gy.M br.M	SE	11–21	S	2	bcp	1014·3	18·3	17·2	mod. av. S swell
WS 687	07° 42′ S, 82° 09′ W	17–18 vii	2216	4594	SE	11–21	SSE	2	cp	1014·2	18·9	16·6	mod. av. S swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS: Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	BIOLOGICAL OBSERVATIONS: Gear	Depth (metres)	TIME: From	To	Remarks
WS 683	26	0	20·18	35·57	25·17	—	—	**N 50 V**	100–0	**2008**	**2010**	
								N 70 B	91–0	**2019**	**2039**	KT
								N 100 B				
WS 684	26	0	17·27	35·12	25·56	—	—	**N 50 V**	55–5	1041	1042	
		10	17·05	35·12	25·61	—	—	**N 70 B**	25–0	1051	1111	KT
		20	16·60	35·11	25·72	—	—	**N 100 B**				
		30	15·50	35·10	25·96	—	—	**N 50 H**	0	1100	1102	
		40	15·12	35·05	26·00	—	—	**N 70 H**	0	1105	1120	Net damaged
		50	15·00	35·06	26·03							
		60	14·97	35·06	26·04							
WS 685	0	0	17·13	35·08	25·56	—	—	**N 50 V**	50–0	1746	1747	
		10	16·15	35·10	25·81	—	—	**N 70 B**	31–0	1757	**1817**	KT
		20	15·64	35·08	25·91	—	—	**N 100 B**				
		30	15·59	35·09	25·93							
		40	15·10	35·08	26·03							
		50	15·08	35·06	26·01							
		60	14·80	35·05	26·07							
WS 686	2	0	20·24	35·47	25·08	0·82	—	**N 50 V**	100–0	**0338**	**0340**	
		10	20·25	35·47	25·08	—	—	**N 70 B**	71–0	**0431**	**0450**	KT
		20	20·25	35·46	25·07	0·82	—	**N 100 B**				
		30	20·25	35·46	25·07	—	—	**N 100 B**	200–70	**0431**	**0457**	Depth estimated
		40	20·17	35·44	25·07	1·03						
		50	19·15	35·27	25·21							
		60	17·44	35·15	25·54	1·56						
		80	16·18	35·11	25·81							
		100	15·40	35·11	25·99	1·82						
		150	14·53	35·06	26·13							
		200	13·90	35·00	26·23	2·22						
		300	12·29	34·88	26·46							
		400	10·16	34·71	26·72	2·85						
		600	7·32	34·58	27·07							
		800	5·90	34·58	27·26	3·02						
		1000	4·78	34·55	27·37							
		1500	3·18	34·65	27·61	3·02						
		2000	1·91	34·63	27·71							
		2500	1·71	34·58	27·68	3·02						
		3000	1·71	34·58	27·68							
		3500	1·64	34·62	27·73	2·57						
WS 687	2	0	19·64	35·26	25·07	0·82	—	**N 50 V**	100–0	**2332**	**2334**	
		10	19·64	35·26	25·07	—	—	**N 70 B**	101–0	**0446**	**0506**	KT
		20	19·64	35·26	25·08	0·82	—	**N 100 B**				
		30	19·64	35·26	25·08	—	—	**N 100 B**	265–100	**0446**	**0517**	Depth estimated
		40	19·64	35·27	25·09	0·95						
		50	19·63	35·27	25·09							
		60	18·83	35·21	25·25	1·22						
		80	16·81	35·16	25·70							
		100	15·00	35·11	26·08	1·69						
		150	13·74	35·01	26·27							
		200	12·89	34·95	26·40	2·22						
		300	11·32	34·85	26·61							
		400	9·17	34·73	26·90	2·22						
		600	7·31	34·61	27·10							
		800	6·16	34·58	27·22	3·42						
		1000	4·79	34·55	27·37							
		1500	3·23	34·59	27·56	3·02						
		2000	2·32	34·64	27·68							
		2500	2·12	34·64	27·70	2·85						
		3000	1·78	34·64	27·73							
		3500	1·79	34·69	27·75	2·57						
		4000	1·73	34·68	27·76							

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 688	07° 19′ S, 81° 35′ W	1931 18 vii	1156	—	SSE	4–10	S	3	bc	1013·1	19·2	17·8	mod. short to mod. av. S swell
WS 689	07° 01′ S, 81° 09′ W	18 vii	1915	2094 gn.M	SSE	7–10	S	3	c	1013·0	18·3	17·8	mod. av. S swell
WS 690	07° 03′ S, 80° 40·6′ W	19 vii	0221	95	SSE	7–16	S	2	bc	1012·5	18·3	17·8	mod. short to mod. av. S swell
WS 691	06° 59·8′ S, 80° 15′ W	19 vii	0553	68 R.Sh	SE	4–10	SE	2	c	1013·4	17·8	16·7	low long to mod. short S swell
WS 692	06° 29·3′ S, 80° 33′ W (I)	19 vii	1017	26 gy.S.Sh	S	1–10	SSE	1	c	1014·9	18·1	17·2	low long S swell
	06° 28·2′ S, 80° 37′ W (II)		1115	—	—	—	—	—	—	—	—	—	—
	06° 29·2′ S, 80° 41·6′ W (III)		1157	—	SE	7–10	SE	2	cm	1014·7	18·3	17·4	low long SSE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 688	3	0	18·64	35·14	25·24	1·31	4·80	**N 70 V**	1000–800	1300		
		10	18·58	35·12	25·24	—	—	,,	800–500			
		20	18·56	35·09	25·22	1·31	4·11	,,	500–250			
		30	18·55	35·09	25·22	—	—	,,	250–100			
		40	18·50	35·10	25·25	1·31	3·83	,,	50–0			
		50	18·17	35·15	25·37	—	—	,,	100–50			
		60	17·00	35·12	25·62	1·90	1·41	**N 50 V**	50–0			
		80	15·51	35·08	25·94	—	—	,,	100–50	—	1455	
		100	14·55	35·03	26·11	2·24	0·62	**N 70 B**	91–0	1509	1529	KT
		150	13·51	35·00	26·31	—	—	**N 100 B**				
		200	12·64	34·95	26·45	2·24	0·26	**N 100 B**	240–90	1509	1539	Depth estimated
		300	11·32	34·84	26·61							
		400	9·01	34·67	26·88	2·74	0·17					
		600	6·73	34·57	27·14							
		800	5·45	34·55	27·29	2·74	0·91					
		1000	4·59	34·54	27·38							
		1500	2·97	34·58	27·58	2·74	1·64					
		2000	2·28	34·61	27·67							
		2500	1·86	34·64	27·72	2·74	2·20					
		3000	1·79	34·64	27·72							
		3500	1·79	34·68	27·75	2·47	2·19					
WS 689	3	0	18·54	35·07	25·21	1·31	—	**N 50 V**	100–0	**2115**	**2117**	
		10	18·45	35·17	25·31	—	—	**N 70 B**	130–0	**2201**	**2221**	KT
		20	18·12	35·08	25·32	1·62	—	**N 100 B**				
		30	17·51	35·08	25·47	—	—	**N 100 B**	340–130	**2201**	**2228**	Depth estimated
		40	17·08	35·07	25·56	1·90						
		50	16·00	35·08	25·83							
		60	15·70	35·06	25·88	1·98						
		80	15·50	35·07	25·93							
		100	15·15	35·07	26·01	2·22						
		150	14·11	35·01	26·19							
		200	13·50	34·97	26·29	2·53						
		300	12·20	34·88	26·48							
		400	9·66	34·71	26·81	2·97						
		600	7·60	34·62	27·07							
		800	5·70	34·55	27·26	2·97						
		1000	4·77	34·55	27·37							
		1500	3·19	34·60	27·57	2·97						
		2000	2·16	34·60	27·66							
WS 690	4	0	18·12	35·12	25·35	1·62	—	**N 50 V**	90–0	**0307**	**0309**	
		10	18·12	35·12	25·35							
		20	17·80	35·12	25·43	1·62						
		30	16·72	35·12	25·69							
		40	16·60	35·10	25·71	1·90						
		50	16·20	35·11	25·81							
		60	15·70	35·09	25·90	2·24						
		80	15·10	35·08	26·03							
		90	15·09	35·08	26·03	2·24						
WS 691	3	0	17·39	35·14	25·55	1·62	—	**N 50 V**	50–0	**0628**	**0630**	
		10	17·35	35·13	25·55							
		20	17·21	35·13	25·58	1·62						
		30	16·50	35·14	25·76							
		40	15·95	35·14	25·88	1·90						
		50	15·70	35·13	25·93							
		60	15·70	35·13	25·93	2·15						
WS 692	4	0	17·40	35·12	25·53	1·75	3·42	**N 70 H**	0–5	1048	1108	Haul I
		10	17·19	35·12	25·58	—	—	**N 100 H**	0–10			
		20	17·00	35·16	25·65	2·13	1·76	**N 50 H**	0–5	1059	1101	
	4	—	—	—	—	—	—	**N 70 H**	0–5	1135	1155	Haul II
								N 100 H	0–10			
	4	—	—	—	—	—	—	**N 70 H**	0–5	1157	1217	Haul III

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 693	06° 35·2′ S, 80° 40′ W	1931 19 vii	1310	40 h	SSE	7–10	SSE	2	omr	1013·7	18·2	17·5	low long SSE swell
WS 694	06° 38′ S, 80° 49·9′ W	19 vii	1508	1216 gn.M. bl.G. Sh	SSE	7–10	SSE	2	cp	1012·3	18·6	18·1	low long SSE swell
WS 695	06° 48·2′ S, 80° 55′ W	19 vii	2100	967 d.gn.M	SSE	4–6	S	2	c	1015·2	18·5	17·8	mod. av. SSE swell
WS 696	06° 54·8′ S, 81° 02′ W	20 vii	0025	1902 gy.M	SSE	7–10	SSE	2	b	1014·7	18·4	17·1	mod. av. SSE swell
WS 697	05° 55·5′ S, 81° 09′ W	21 vii	1025	75 bl.S.M	SSW	7–16	S	2	c	1014·7	18·2	16·7	mod. av. SSW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 693	4	0	17·81	35·16	25·45	1·82	—	**N 50 V**	35–0	1333	1334	
		10	17·46	35·12	25·51	—	—	**N 70 B**	29–0	1340	1400	KT
		20	17·31	35·13	25·56	1·98	—	**N 100 B**				
		30	16·28	35·13	25·80							
		35	16·22									
WS 694	4	0	18·13	35·13	25·36	1·82	4·07	**N 70 V**	50–0	1703		
		10	17·76	35·13	25·45	—	—	,,	100–50			
		20	17·28	35·13	25·56	1·98	2·43	,,	250–100			
		30	16·47	35·10	25·74	—	—	,,	500–250			
		40	15·85	35·09	25·87	2·41	0·61	,,	100–50			
		50	15·56	35·09	25·94	—	—	,,	750–500			
		60	15·30	35·09	25·99	2·22	1·09	,,	1000–750			
		80	14·86	35·08	26·08	—	—	**N 50 V**	100–0	—	1855	
		100	14·72	35·08	26·11	1·90	1·43	**N 70 B**	128–0	1918	1937	KT
		150	14·20	35·01	26·17	—	—	**N 100 B**				
		200	13·70	35·00	26·27	1·90	0·55	**N 100 B**	340–130	1918	1948	Depth estimated
		300	11·81	34·90	26·57							
		400	9·36	34·72	26·86	2·74	0·39					
		600	7·69	34·63	27·05							
		800	5·58	34·59	27·31	2·74	1·08					
		1000	4·12	34·58	27·46							
WS 695	4	0	18·12	35·12	25·35	1·90	—	**N 50 V**	100–0	2206	2208	
		10	18·02	35·11	25·38	—	—	**N 100 B**	170–60	2250	2317	Depth estimated
		20	16·35	35·12	25·78	2·05	—	**N 70 B**	58–0	2250	2310	KT
		30	16·12	35·13	25·84	—	—	**N 100 B**				
		40	15·82	35·12	25·90	2·05						
		50	15·45	35·10	25·97							
		60	15·28	35·10	26·01	2·15						
		80	14·99	35·09	26·06							
		100	14·79	35·07	26·09	2·24						
		150	14·00	35·03	26·23							
		200	13·21	34·97	26·35	2·36						
		300	11·41	34·88	26·63							
		400	9·51	34·74	26·85	2·47						
		600	7·62	34·62	27·06							
		800	5·57	34·58	27·30	2·47						
		900	5·05	34·58	27·36							
WS 696	5	0	18·21	35·11	25·33	1·98	4·33	**N 50 V**	100–0	0142	0144	
		10	18·21	35·11	25·33	—	—	**N 70 B**	73–0	0233	0253	KT
		20	18·00	35·09	25·36	1·90	4·00	**N 100 B**				
		30	17·21	35·08	25·54	—	—	**N 100 B**	205–75	0233	0302	Depth estimated
		40	16·81	35·07	25·63	2·05	1·50					
		50	16·13	35·07	25·79							
		60	15·70	35·07	25·88	2·05	1·41					
		80	15·33	35·05	25·95							
		100	15·24	35·05	25·97	2·05	1·47					
		150	14·70	35·05	26·09							
		200	13·81	34·97	26·23	2·47	0·84					
		300	11·35	34·79	26·57							
		400	9·51	34·67	26·80	2·47	0·22					
		600	7·66	34·61	27·05							
		800	5·51	34·53	27·27	2·91	0·35					
		1000	4·58	34·51	27·35							
		1500	3·29	34·58	27·55	2·91	1·74					
WS 697	6	0	16·50	35·06	25·69	—	2·52	**N 50 V**	50–0	1104	1105	
		10	15·92	35·08	25·84	—	—	**N 70 B**	37–0	1114	1134	KT
		20	15·80	35·06	25·85	—	1·46	**N 100 B**				
		30	15·55	35·14	25·98							
		40	15·50	35·03	25·90	—	1·06					
		50	15·43	35·05	25·93							
		60	15·36	35·03	25·93	—	1·54					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 698	05° 55′ S, 81° 09·8′ W	1931 21 vii	1139	88	S × W	17–21	S × W	2	c	1014·0	18·1	16·7	low av. S swell
WS 699	05° 54′ S, 81° 11·7′ W	21 vii	1255	117	S × W	11–16	S × W	3	bc	1013·6	18·6	17·2	low long S swell
WS 700	05° 52′ S, 81° 15·5′ W	21 vii	1426	313 gn.M	S × E	17–21	S × E	3	bc	1012·5	20·1	19·2	low long S × E swell
WS 701	05° 48′ S, 81° 22·5′ W	21 vii	1656	1086 gy.M	S	7–16	S	3	bc	1011·4	18·9	17·8	mod. av. S swell
WS 702	05° 38′ S, 81° 40′ W	21–22 vii	2226	3202 br.M	S	7–16	S	2	bc	1014·2	17·9	17·1	mod. av. SW swell

Station	Age of moon (days)	Hydrological observations: Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	Biological observations: Gear	Depth (metres)	Time: From	Time: To	Remarks
WS 698	6	0	16·60	35·03	25·65	—	—	N 50 V	50–0	1208	1209	
		10	16·40	35·06	25·72	—	—	N 70 B	70–0	1224	1244	KT
		20	16·00	35·06	25·81	—	—	N 100 B				
		30	15·87	35·04	25·83							
		40	15·54	35·03	25·89							
		50	15·48	35·04	25·92							
		60	15·40	35·03	25·92							
		80	15·25	35·07	25·99							
WS 699	6	0	17·76	35·06	25·39	—	2·57	N 50 V	100–0	1337	1339	Much stray on wire
		10	17·09	35·05	25·54	—	—	N 70 B	85–0	1350	1410	KT
		20	16·05	35·05	25·79	—	1·33	N 100 B				
		30	15·95	35·05	25·81							
		40	15·75	35·05	25·86	—	1·35					
		50	15·50	35·06	25·92							
		60	15·40	35·06	25·94							
		80	15·31	35·06	25·96							
		100	15·10	35·06	26·01	—	1·08					
WS 700	6	0	18·24	35·13	25·33	—	—	N 50 V	100–0	1432	1434	
		10	17·71	35·09	25·43	—	—	N 70 B	73–0	1543	1604	KT
		20	16·71	35·12	25·69	—	—	N 100 B				
		30	16·28	35·13	25·80	—	—	N 100 B	205–73	1543	1614	Depth estimated
		40	15·99	35·06	25·81							
		50	15·71	35·07	25·88							
		60	15·50	35·08	25·94							
		80	15·23	35·07	25·99							
		100	15·11	35·07	26·02							
		150	14·70	35·05	26·09							
		200	14·20	35·05	26·19							
		270	13·95	35·04	26·25							
WS 701	6	0	18·47	35·11	25·26	—	4·75	N 50 V	100–0	**1813**	**1815**	
		10	18·12	35·11	25·35	—	—	N 70 V	50–0	**1825**		
		20	16·60	35·14	25·73	—	2·18	,,	100–50			
		30	16·40	35·11	25·76	—	—	,,	250–100			
		40	16·07	35·15	25·87	—	1·71	,,	500–250			
		50	15·91	35·15	25·90	—	—	,,	100–50			
		60	15·77	35·17	25·96	—	1·56	,,	750–500			
		80	15·36	35·13	26·01	—	—	,,	1000–0	—	**2015**	
		100	15·10	35·12	26·06	—	1·45	N 70 B	59–0	**2023**	**2044**	KT
		150	14·72	35·23	26·23	—	—	N 100 B				
		200	14·59	35·08	26·14	—	1·26	N 100 B	170–60	**2023**	**2050**	Depth estimated
		300	12·90	34·97	26·42							
		400	10·71	34·81	26·70	—	0·18					
		600	7·47	34·71	27·15							
		800	6·72	34·61	27·17	—	0·50					
		1000	5·72	34·75	27·42							
WS 702	6	0	18·31	35·11	25·30	—	—	N 50 V	100–0	**0104**	**0106**	
		10	18·31	35·14	25·32	—	—	N 70 B	60–0	**0133**	**0153**	KT
		20	18·22	35·11	25·33	—	—	N 100 B				
		30	17·51	35·15	25·53	—	—	N 100 B	170–60	**0133**	**0200**	Depth estimated
		40	16·60	35·13	25·72							
		50	16·18	35·12	25·81							
		60	15·41	35·11	25·99							
		80	15·30	35·12	26·01							
		100	15·10	35·11	26·06							
		150	14·80	35·27	26·25							
		200	14·15	35·07	26·22							
		300	12·62	34·96	26·45							
		400	9·57	34·79	26·88							
		600	7·40	34·67	27·12							
		800	5·27	34·74	27·46							
		1000	4·75	34·59	27·40							
		1500	3·39	34·61	27·56							

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 702 *cont.*	05° 38′ S, 81° 40′ W	1931 21–22 vii											
WS 703	05° 34′ S, 82° 11·5′ W	22 vii	0700	4724 gy.M	SE	4–10	ESE	2	c	1015·2	18·4	17·2	mod. av. SE swell
WS 704	05° 33′ S, 82° 47′ W	22 vii	1659	—	SE	4–6	SE	1	c	1011·7	19·6	17·8	mod. short SSE swell
WS 705	05° 35·5′ S, 83° 41·8′ W	23 vii	0230	4027 gy.M	SSW	1–6	SE	2	bc	1013·6	19·0	17·7	mod. av. SSE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 702 *cont.*	6	2000	2·52	34·67	27·69							
		2500	2·10	34·70	27·74							
		3000	1·85	34·70	27·76							
WS 703	7	0	18·16	35·12	25·34	—	4·56	**N 50 V**	100–0	0915	0917	
		10	18·12	35·13	25·36	—	—	**N 70 B**	68–0	1232	1252	KT
		20	17·97	35·13	25·39	—	4·29	**N 100 B**				
		30	17·58	35·14	25·50	—	—	**N 100 B**	195(–0)	1232	1259	Depth estimated
		40	16·59	35·13	25·73	—	2·47					
		50	16·65	35·13	25·71							
		60	15·70	35·11	25·92	—	1·60					
		80	15·50	35·11	25·97							
		100	15·29	35·10	26·01	—	1·79					
		150	14·90	35·07	26·06							
		200	14·55	35·06	26·13	—	1·14					
		300	12·60	34·97	26·46							
		400	10·11	34·79	26·79	—	0·23					
		600	7·44	34·64	27·10							
		800	6·06	34·55	27·22	—	0·66					
		1000	4·66	34·57	27·39							
		1500	3·08	34·61	27·60	—	1·91					
		2000	2·45	34·64	27·67							
		2500	1·94	34·65	27·71	—	2·60					
		3000	1·77	34·68	27·76							
		3500	1·77	34·68	27·76	—	2·58					
		4000	1·75	34·68	27·76							
		4500	1·81	—	—	—	2·72					
WS 704	7	0	18·63	35·11	25·22	—	—	**N 50 V**	100–0	1800	1802	
		10	18·05	35·11	25·37	—	—	**N 70 B**	60–0	**2004**	**2024**	KT
		20	17·41	35·11	25·52	—	—	**N 100 B**				
		30	17·17	35·11	25·58	—	—	**N 100 B**	170–60	**2004**	**2030**	Depth estimated
		40	17·07	35·14	25·62							
		50	16·96	35·13	25·64							
		60	16·91	35·15	25·67							
		80	16·40	35·14	25·78							
		100	15·57	35·07	25·91							
		150	15·20	35·09	26·02							
		200	14·50	35·03	26·12							
		300	12·35	35·01	26·55							
		400	9·41	34·72	26·85							
		600	7·03	34·62	27·15							
		800	5·58	34·58	27·30							
		1000	4·64	34·58	27·41							
		1500	3·08	34·66	27·63							
		2000	2·35	34·66	27·69							
		2500	1·89	34·70	27·76							
		3000	1·81	34·69	27·75							
		3500	1·79	34·69	27·75							
		3900	1·81	34·68	27·75							
WS 705	8	0	19·02	35·11	25·12	—	4·29	**N 50 V**	100–0	**0406**	**0408**	
		10	19·02	35·20	25·19	—	—	**N 70 V**	50–0	**0414**		
		20	19·02	35·11	25·12	—	4·65	,,	100–50			
		30	18·83	35·09	25·15	—	—	,,	250–100			
		40	16·82	35·14	25·68	—	1·90	,,	500–250			
		50	16·22	35·11	25·81	—	—	,,	750–0			
		60	15·50	35·08	25·94	—	1·09	,,	750–500			
		80	14·94	35·06	26·05	—	—	,,	1000–750	—	0746	
		100	14·76	35·05	26·07	—	1·39	**N 70 B**	91–0	0806	0826	KT
		150	14·35	35·01	26·14	—	—	**N 100 B**				
		200	13·72	35·01	26·28	—	0·50	**N 100 B**	240–90	0806	0834	Depth estimated
		300	12·20	34·93	26·51							
		400	10·21	34·81	26·79	—	0·43					
		600	6·81	34·61	27·16							
		800	5·42	34·53	27·28	—	1·79					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 705 *cont.*	05° 35·5′ S, 83° 41·8′ W	1931 23 vii											
WS 706	05° 37·5′ S, 83° 58′ W	23 vii	0955	—	ESE	4–10	S	2	c	1015·2	21·1	18·3	mod. av. S swell
WS 707	05° 37·5′ S, 84° 31·5′ W	23 vii	1528	—	SE	7–10	SE	2	c	1011·9	20·6	18·6	mod. short SE swell
WS 708	04° 18′ S, 82° 05′ W	24–25 vii	2239	4294 gy.M	SSE	4–6	SSE	2	c	1014·1	18·6	17·8	low long SE swell
WS 709	04° 17′ S, 81° 16·8′ W	25 vii	1040	40	SSW	17–21	S	3	c	1015·4	20·0	18·7	mod. av. S swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	BIOLOGICAL OBSERVATIONS Gear	Depth metres)	TIME From	To	Remarks
WS 705 *cont.*	8	1000	4·53	34·53	27·38							
		1500	3·06	34·59	27·58	—	2·40					
		2000	2·31	34·61	27·65							
		2500	1·95	34·67	27·73	—	2·02					
		3000	1·79	34·67	27·74							
		3500	1·79	34·68	27·75	—	2·73					
		3900	1·82	34·69	27·75							
WS 706	8	0	19·74	35·16	24·97	—	—	**N 50 V**	100–0	1056	1058	
		10	19·72	35·13	24·95	—	—	**N 70 B**	73–0	1118	1139	KT
		20	19·49	35·12	25·00	—	—	**N 100 B**				
		30	18·94	35·12	25·14	—	—	**N 100 B**	205(–0)	1118	1155	Depth estimated
		40	17·50	35·09	25·48	—	—	**NH**	0	1120		
		50	16·82	35·12	25·67							
		60	15·62	35·11	25·94							
		80	14·99	35·09	26·06							
		100	14·79	35·08	26·10							
		150	14·21	35·06	26·20							
		200	13·35	35·00	26·34							
		300	12·20	34·93	26·51							
		400	10·10	34·76	26·76							
WS 707	8	0	20·69	35·16	24·71	—	5·12	**NH**	0	1630		
		10	20·48	35·16	24·77	—	—	**N 50 V**	100–0	1640	1642	
		20	20·42	35·16	24·79	—	3·95	**N 70 B**	115–0	1717	1736	KT
		30	20·24	35·17	24·85	—	—	**N 100 B**				
		40	17·29	35·11	25·55	—	2·17	**N 100 B**	315–115	1717	1747	Depth estimated
		50	16·18	35·08	25·78							
		60	15·80	35·08	25·87	—	0·89					
		80	15·00	35·08	26·05							
		100	14·51	35·07	26·15	—	1·69					
		150	13·80	35·00	26·25							
		200	13·22	34·98	26·36	—	0·45					
		300	11·61	34·86	26·57							
		400	9·40	34·71	26·85	—	0·38					
		600	6·86	34·57	27·12							
		800	5·70	34·54	27·25	—	1·07					
		1000	4·68	34·54	27·37							
WS 708	9	0	18·50	34·81	25·03	—	3·83	**N 50 V**	100–0	**2353**	**2355**	
		10	18·51	34·82	25·03	—	—	**N 70 V**	50–0	**0000**		
		20	15·72	35·07	25·88	—	1·04	,,	100–50			
		30	15·50	35·08	25·94	—	—	,,	250–100			
		40	15·39	35·07	25·95	—	1·92	,,	500–250			
		50	15·30	35·07	25·97	—	—	,,	750–500			
		60	15·29	35·07	25·98	—	2·17	,,	1000–750	—	**0145**	
		80	15·20	35·07	26·00	—	—	**N 70 B**	73–0	**0321**	**0341**	Depth estimated
		100	15·00	35·04	26·02	—	1·60	**N 100 B**				
		150	14·60	35·04	26·11	—	—	**N 100 B**	205–75	**0321**	**0349**	Depth estimated
		200	14·30	35·00	26·14	—	1·43					
		300	12·30	34·87	26·45							
		400	9·24	34·70	26·87	—	0·36					
		600	8·05	34·70	27·06							
		800	6·41	34·56	27·17	—	0·78					
		1000	5·36	34·55	27·30							
		1500	3·54	34·56	27·50	—	1·82					
		2000	2·54	34·64	27·66							
		2500	2·20	34·64	27·69	—	1·99					
		3000	1·82	34·67	27·74							
		3500	1·80	34·85	27·88	—	2·69					
		4000	1·83	34·90	27·93							
WS 709	10	0	22·64	34·15	23·42	0·84	4·05	**N 50 V**	15–0	1115	1116	
		10	21·34	34·39	23·96	—	—	,,	30–15	1129	1130	
		20	16·50	35·08	25·71	1·56	2·03	**N 70 B**	20–0	1135	1155	KT
		30	16·30	35·08	25·76	—	—	**N 100 B**				

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 710	04° 18′ S, 81° 21·3′ W	1931 25 vii	1220	62 h	S	17–21	S	3	bc	1012·1	20·0	18·6	mod. av. S swell
WS 711	04° 19·5′ S, 81° 27′ W	25 vii	1352	1885 gn.M	S	17–27	S	4	bc	1012·1	19·4	17·8	mod. av. S swell
WS 712	04° 20′ S, 81° 37·8′ W	25 vii	1815	—	S	11–21	S	4	bc	1012·4	18·6	17·8	mod. av. S swell
WS 713	04° 20′ S, 81° 47′ W	25 vii	2150	—	SSE	7–16	S	3	bc	1013·9	17·3	16·8	mod. av. S swell
WS 714	04° 20′ S, 81° 57·5′ W	26 vii	0055	—	S × E	11–16	S × E	3	o	1014·2	16·7	15·6	mod. av. S × E swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 710	10	0	21·53	34·44	23·95	0·84	—	N 50 V	15–0	1255		
		10	21·24	34·53	24·09	—	—	,,	60–15	—	1301	
		20	16·91	35·08	25·61	1·56	—	N 70 B	44–0	1310	1330	KT
		30	16·03	35·13	25·86	—	—	N 100 B				
		40	15·70	35·14	25·94	1·56						
		50	15·60	35·10	25·94							
		60	15·50	35·07	25·93	1·56						
WS 711	10	0	21·19	34·53	24·10	0·68	4·04	N 70 V	50–0	1525		
		10	21·01	34·57	24·18	—	—	,,	100–50			
		20	18·60	34·92	25·08	0·82	2·76	,,	250–100			
		30	16·20	35·09	25·79	—	—	,,	500–250			
		40	15·90	35·12	25·88	1·50	2·17	,,	750–500			
		50	15·62	35·07	25·90	—	—	,,	1000–750	—	1700	
		60	15·60	35·07	25·91	1·43	1·84	N 50 V	100–0	1705	1707	
		80	15·44	35·07	25·94	—	—	N 70 B	83–0	1726	1746	KT
		100	15·40	35·08	25·96	1·50	1·66	N 100 B				
		150	15·00	35·04	26·02	—	—	N 100 B	225–85	1726	1806	Depth estimated
		200	14·70	35·03	26·08	1·56	1·18					
		300	12·00	34·88	26·52							
		400	9·78	34·73	26·80	1·69	0·29					
		600	7·19	34·61	27·11							
		800	5·77	34·61	27·29	1·90	0·83					
		1000	4·66	34·63	27·44							
		1500	3·09	34·60	27·58	1·77	1·65					
WS 712	10	0	20·44	34·68	24·42	0·13	—	N 50 V	100–0	**1957**	**1959**	
		10	20·10	34·72	24·54	—	—	N 70 B	57–0	**2019**	**2039**	KT
		20	16·60	35·08	25·69	0·13	—	N 100 B				
		30	16·29	35·08	25·76	—	—	N 100 B	165–55	**2019**	**2046**	Depth estimated
		40	15·85	35·10	25·88	0·55						
		50	15·51	35·10	25·96							
		60	15·48	35·09	25·95	0·82						
		80	15·40	35·09	25·97							
		100	15·36	35·09	25·98	1·03						
		150	14·86	35·09	26·09							
		200	14·10	35·08	26·24	1·16						
		300	11·80	35·00	26·65							
		400	9·91	34·75	26·80	1·63						
WS 713	10	0	16·85	35·21	25·73	0·55	2·83	N 50 V	100–0	**2308**	**2310**	
		10	16·82	35·01	25·59	—	—	N 70 B	80–0	**2326**	**2346**	KT
		20	16·81	35·05	25·61	0·82	2·66	N 100 B				
		30	16·79	35·03	25·60	—	—	N 100 B	220–80	**2326**	**2355**	Depth estimated
		40	16·72	35·03	25·62	0·82	2·74					
		50	16·62	35·03	25·64							
		60	16·00	35·05	25·80	0·82	2·19					
		80	15·62	35·10	25·93							
		100	15·36	35·10	25·99	1·16	1·73					
		150	14·90	35·04	26·04							
		200	14·15	35·02	26·20	1·22	1·11					
		300	11·80	34·89	26·56							
		400	9·71	34·77	26·84	1·90	0·30					
		600	7·14	34·65	27·14							
		800	5·57	34·59	27·31	2·05	1·19					
		1000	4·65	34·62	27·45							
		1500	3·10	34·64	27·61	2·13	2·41					
WS 714	11	0	17·01	35·02	25·55	—	—	N 50 V	100–0	**0158**	**0200**	
		10	17·01	35·06	25·57							
		20	16·97	35·06	25·58							
		30	15·79	35·05	25·85							
		40	15·45	35·10	25·97							
		50	15·39	35·07	25·95							
		60	15·33	35·08	25·98							
		80	15·25	35·10	26·02							

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 714 *cont.*	04° 20′ S, 81° 57·5′ W	1931 26 vii											
WS 715	02° 11·3′ S, 81° 04′ W	31 vii	1554	60 R	S	7–10	S	3	oc	1011·5	22·6	20·4	mod. short SSW swell
WS 716	02° 11′ S, 81° 09′ W	31 vii	1718	90 R	S	7–10	S	3	c	1011·0	22·2	20·3	mod. short SSW swell
WS 717	02° 12′ S, 81° 18·5′ W	31 vii	1917	1650 gy.M	SSW	7–10	S	3	c	1012·3	21·6	18·8	mod. short SSW swell
WS 718	02° 11′ S, 81° 33·5′ W	1 viii	0022	—	SW × S	7–10	SW × S	3	o	1014·3	21·4	20·0	mod. av. SW × S swell
WS 719	02° 11′ S, 81° 53′ W	1 viii	0435	3109	SSW	4–6	SSW	2	cm	1012·2	20·3	19·2	mod. short SSW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S °/°°	σt	P. mg. atom m.³	O_2 c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS714 *cont.*	11	100	15·19	35·07	26·00							
		150	14·59	35·04	26·11							
		200	13·91	35·01	26·24							
		300	11·70	34·86	26·55							
		400	9·91	34·78	26·82							
WS715	16	0	24·30	33·76	22·64	—	—	**N 50 V**	50–0	1617	1618	
		10	24·29	33·76	22·64	—	—	**N 70 B**	54–0	1627	1647	KT
		20	22·28	33·98	23·39	—	—	**N 100 B**				
		30	20·24	34·50	24·33							
		40	17·62	34·83	25·25							
		50	15·90	35·01	25·80							
WS716	16	0	24·43	33·79	22·63	—	—	**N 50 V**	50–0	1744	1745	
		10	24·45	33·82	22·64	—	—	**N 70 B**	90–0	1754	1814	KT
		20	24·41	33·83	22·66	—	—	**N 100 B**				
		30	20·95	34·41	24·08							
		40	19·52	34·71	24·69							
		50	16·58	34·97	25·62							
		60	15·20	35·03	25·97							
		80	15·01	35·04	26·02							
WS717	17	0	24·22	33·83	22·72	—	—	**N 50 V**	100–0	**2017**	**2019**	
		10	24·22	33·83	22·72	—	—	**N 70 V**	50–0	**2024**		
		20	24·22	33·83	22·72	—	—	,,	100–50			
		30	20·45	34·51	24·29	—	—	,,	250–500			
		40	18·59	34·77	24·97	—	—	,,	500–250			
		50	15·42	35·04	25·93	—	—	,,	750–500			
		60	15·29	35·03	25·95	—	—	,,	1000–750	—	**2200**	
		80	15·21	35·08	26·00	—	—	**N 70 B**	101–0	**2219**	**2239**	KT
		100	15·19	35·05	25·98	—	—	**N 100 B**				
		150	14·50	35·03	26·12	—	—	**N 100 B**	265–100	**2219**	**2245**	Depth estimated
		200	14·21	34·99	26·15							
		300	11·51	34·83	26·57							
		400	9·58	34·71	26·82							
		600	7·24	34·61	27·10							
		800	5·42	34·58	27·32							
		1000	4·60	34·56	27·39							
		1500	3·49	34·61	27·55							
WS718	17	0	23·85	33·87	22·86	—	—	**N 50 V**	100–0	**0126**	**0128**	
		10	23·84	33·87	22·86	—	—	**N 70 B**	128–0	**0148**	**0208**	KT
		20	23·82	33·87	22·87	—	—	**N 100 B**				
		30	19·41	34·65	24·66	—	—	**N 100 B**	340–130	**0148**	**0220**	Depth estimated
		40	17·71	34·97	25·34							
		50	15·89	35·05	25·82							
		60	15·59	35·06	25·90							
		80	15·46	35·03	25·91							
		100	15·11	35·07	26·02							
		150	14·79	35·00	26·04							
		200	14·32	34·99	26·13							
		300	11·65	34·84	26·55							
		400	10·17	34·73	26·73							
WS719	17	0	23·00	33·91	23·13	—	4·79	**N 50 V**	100–0	**0557**	**0559**	
		10	23·00	33·91	23·13	—	—	**N 70 V**	50–0	**0604**		
		20	22·99	34·06	23·25	—	4·69	,,	100–50			
		30	18·11	34·81	25·12	—	—	,,	250–100			
		40	16·95	35·04	25·58	—	1·73	,,	500–250			
		50	16·10	35·06	25·79	—	—	,,	750–500	—	0730	
		60	15·75	35·06	25·87	—	2·12	**N 70 B**	103–0	0837	0857	KT
		80	15·39	35·08	25·96	—	—	**N 100 B**				
		100	15·21	35·04	25·98	—	2·01	**N 100 B**	270–103	0837	0905	Depth estimated
		150	14·76	35·01	26·05	—	—	**TYFB**	550(–0)	0837	0920	Depth estimated
		200	14·28	34·99	26·14	—	1·07					
		300	12·20	34·89	26·48							

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 719 *cont.*	02° 11′ S, 81° 53′ W	1931 1 viii											
WS 720	02° 52·3′ S, 82° 19·5′ W	1 viii	1725	—	S	11–16	S	3–4	oc	1011·5	19·2	17·8	mod. av. S×E swell
WS 721	03° 29′ S, 82° 51′ W	2 viii	0125	—	S×W	11–16	S×W	4	oc	1013·7	18·6	17·2	mod. av. S swell
WS 722	04° 20·4′ S, 83° 03′ W	2 viii	1030	—	SE	7–16	SE	3	c	1014·8	18·9	17·2	mod. av. S swell
WS 723	05° 01·5′ S, 83° 49′ W	2 viii	2130	—	SE	11–21	S	4	c	1013·8	18·5	17·3	mod. av. S swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 719 *cont.*	17	400	10·52	34·71	26·66	—	0·25					
		600	7·57	34·62	27·07							
		800	5·74	34·56	27·26	—	1·14					
		1000	4·97	34·57	27·36							
		1500	3·73	34·61	27·53	—	1·52					
		2000	2·58	34·61	27·64							
		2500	2·02	34·62	27·70	—	2·11					
		3000	1·75	34·67	27·75							
WS 720	17	0	21·06	34·29	23·95	—	—	**N 50 V**	100–0	1828	**1830**	
		10	21·06	34·28	23·95	—	—	**N 70 B**	80–0	**1850**	**1910**	KT
		20	19·95	34·59	24·48	—	—	**N 100 B**				
		30	16·30	35·10	25·78	—	—	**N 100 B**	220–80	**1850**	**1916**	Depth estimated
		40	15·90	35·11	25·88							
		50	15·71	35·12	25·92							
		60	15·54	35·11	25·96							
		80	15·40	35·05	25·93							
		100	15·32	35·11	26·01							
		150	14·80	35·07	26·08							
		200	13·95	35·05	26·25							
		300	12·30	34·94	26·50							
		400	10·11	34·82	26·82							
WS 721	18	0	19·15	34·74	24·81	—	—	**N 50 V**	100–0	**0228**	**0230**	
		10	19·15	34·74	24·81	—	—	**N 70 B**	84–0	**0251**	**0311**	
		20	19·15	34·74	24·81	—	—	**N 100 B**	225 85	**0251**	**0319**	Depth estimated
		30	18·84	34·82	24·95							
		40	18·43	34·97	25·17							
		50	15·79	35·17	25·94							
		60	15·58	35·24	26·05							
		80	15·40	35·15	26·02							
		100	15·20	35·10	26·03							
		150	14·75	35·08	26·10							
		200	14·19	35·07	26·21							
		300	11·80	34·94	26·60							
		400	10·04	34·82	26·83							
WS 722	18	0	18·54	35·06	25·20	—	4·45	**N 50 V**	100–0	1138	1140	
		10	18·54	35·06	25·20	—	—	**N 70 B**	102–0	1321	1341	KT
		20	18·53	35·03	25·18	—	4·40	**N 100 B**				
		30	18·53	35·06	25·20	—	—	**N 100 B**	270–100	1321	1351	Depth estimated
		40	17·81	35·10	25·42	—	2·96	**TYFB**	1200(–0)	1321	1425	Depth estimated
		50	16·32	35·13	25·79							
		60	16·00	35·14	25·87	—	1·63					
		80	15·60	35·12	25·95							
		100	15·22	35·12	26·03	—	1·07					
		150	15·02	35·09	26·06							
		200	14·00	35·07	26·25	—	0·41					
		300	11·85	34·93	26·58							
		400	9·51	34·77	26·87	—	0·23					
		600	7·67	34·65	27·06							
		800	5·81	34·58	27·27	—	0·56					
		1000	4·34	34·57	27·43							
		1500	3·11	34·65	27·61	—	1·60					
		2000	2·36	34·67	27·70							
		2500	1·93	34·67	27·73	—	2·46					
		3000	1·76	34·75	27·82							
		3500	1·72	34·66	27·74	—	1·48					
WS 723	18	0	18·42	35·07	25·24	—	—	**N 50 V**	100–0	**2233**	**2235**	
		10	18·42	35·06	25·23	—	—	**N 70 B**	76–0	**2255**	**2315**	KT
		20	18·44	35·07	25·23	—	—	**N 100 B**				
		30	18·43	35·09	25·25	—	—	**N 100 B**	210–75	**2255**	**2322**	Depth estimated
		40	18·32	35·08	25·27							
		50	16·42	35·17	25·80							
		60	16·14	35·12	25·82							

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 723 *cont.*	05° 01·5′ S, 83° 49′ W	1931 2 viii											
WS 724	05° 35·7′ S, 84° 33′ W	3 viii	0630	—	SSE	11–21	S × E	4	c	1014·0	18·9	16·7	mod. av. SSE swell
WS 725	06° 25′ S, 85° 04·2′ W	3 viii	1432	—	SE	17–27	SE	5	bc	1014·4	18·9	16·8	heavy av. SE swell
WS 726	07° 20′ S, 85° 12·5′ W	4 viii	0006	—	SE	22–27	SE	5	bcqp	1017·1	18·3	18·3	heavy av. SE swell
WS 727	12° 09·5′ S, 77° 15′ W	7 viii	0730	—	SSE	7–10	SSE	3	o	1015·5	15·6	14·4	mod. long SSE swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 723 *cont.*	18	80	15·72	35·13	25·93							
		100	15·24	35·12	26·03							
		150	14·40	35·06	26·16							
		200	13·63	35·04	26·31							
		300	12·41	34·95	26·49							
		400	10·56	34·82	26·74							
WS 724	19	0	20·06	35·20	24·92	—	—	**N 50 V**	100–0	0732	0734	
		10	20·06	35·20	24·92							
		20	20·07	35·18	24·91							
		30	20·03	35·23	24·95							
		40	19·96	35·22	24·97							
		50	17·01	35·23	25·71							
		60	15·68	35·16	25·96							
		80	15·31	35·16	26·04							
		100	14·62	35·08	26·13							
		150	13·99	35·23	26·38							
		200	13·22	34·97	26·34							
		300	11·61	34·86	26·57							
		400	10·01	34·78	26·80							
WS 725	19	0	20·13	35·20	24·90	—	—	**N 50 V**	100–50	1533		
		10	20·10	35·18	24·90	—	—	,,	50–0	—	1545	
		20	20·04	35·20	24·92	—	—	**N 70 B** }	89–0	1607	1626	KT
		30	20·00	35·21	24·94	—	—	**N 100 B** }				
		40	19·96	35·19	24·94	—	—	**N 100 B**	235–90	1607	1632	Depth estimated
		50	19·24	35·21	25·14							
		60	15·78	35·11	25·91							
		80	14·62	35·08	26·13							
		100	14·20	35·08	26·22							
		150	13·50	35·00	26·31							
		200	13·05	34·97	26·38							
		300	11·51	34·89	26·62							
		400	9·89	34·76	26·80							
WS 726	20	0	20·02	35·27	24·99	—	4·94	**N 50 V**	100–50	**0200**		
		10	20·02	35·28	24·99	—	—	,,	50–0	—	**0230**	
		20	20·11	35·25	24·94	—	5·00	**N 70 B** }	130–0	**0349**	**0410**	KT
		30	20·11	35·25	24·94	—	—	**N 100 B** }				
		40	20·03	35·28	24·98	—	4·71	**N 100 B**	340–130	**0349**	**0419**	Depth estimated
		50	20·11	35·27	24·96							
		60	17·60	35·23	25·56	—	1·76					
		80	14·74	35·06	26·09							
		100	14·13	35·09	26·25	—	0·84					
		150	13·41	35·04	26·36							
		200	12·90	34·97	26·41	—	0·26					
		300	11·79	34·89	26·56							
		400	10·26	34·79	26·77	—	0·27					
		600	8·73	34·66	26·91							
		800	6·75	34·64	27·19	—	0·39					
		1000	5·63	34·56	27·27							
		1500	3·68	34·56	27·49	—	1·40					
		2000	2·57	34·61	27·63							
		2500	2·09	34·66	27·71	—	1·80					
		3000	1·79	34·68	27·75							
		3500	1·79	34·70	27·77	—	1·59					
WS 727	23	0	14·88	35·08	26·08	—	—	**N 50 V**	50–0	0813	0814	
		10	14·77	35·08	26·10	—	—	**N 70 H** }	0–5	0824	0844	
		20	14·63	—	—	—	—	**N 100 H** }				
		30	14·61	35·01	26·09							
		40	14·61	35·03	26·10							
		50	14·56	35·18	26·23							
		58	14·57									

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 728	12° 09·5′ S, 77° 15′ W	1931 20 viii	0806	—	SW	4–6	SW	2	o	1011·7	15·3	14·4	low long SW swell
WS 729	12° 11·5′ S, 77° 20′ W	20 viii	0948	—	SW	4–6	SW	1	o	1011·7	15·6	14·4	low long S swell
WS 730	12° 15′ S, 77° 27′ W	20 viii	1204	168	SSW	4–6	—	0	bc	1013·7	16·1	15·0	mod. short SSW swell
WS 731	12° 22′ S, 77° 40′ W	20 viii	1502	—	SSE	4–6	S	2	c	1011·2	16·1	15·2	mod. short S swell
WS 732	12° 36′ S, 78° 07′ W	20 viii	2021	—	S	4–10	S	3	c	1013·2	14·6	13·9	mod. short S swell
WS 733	12° 54·5′ S, 78° 43′ W	21 viii	0500	—	SE	7–10	SE	2	o	1014·0	15·6	13·9	low long SE swell

Station	Age of moon (days)	Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	Gear	Depth (metres)	From	To	Remarks
		HYDROLOGICAL OBSERVATIONS						**BIOLOGICAL OBSERVATIONS**		TIME		
WS 728	7	0	15·73	35·04	25·86	—	—	N 50 V	50–0	0830	0831	
		10	15·59	35·04	25·89	—	—	N 70 V	50–0	0835	0836	
		20	15·36	35·03	25·93	—	—	N 70 B	51–0	0848	0908	KT
		30	14·86	35·02	26·04	—	—	N 100 B				
		40	14·43	35·00	26·12							
		50	14·11	35·00	26·18							
WS 729	7	0	16·64	35·17	25·76	—	—	N 50 V	100–0	1023	1025	
		10	16·47	35·12	25·75	—	—	N 70 V	50–0	1035		
		20	15·71	35·08	25·89	—	—	,,	100–50	—	1050	
		30	14·70	35·02	26·08	—	—	N 70 B	80–0	1058	1118	KT
		40	14·51	35·01	26·11	—	—	N 100 B				
		50	14·25	34·99	26·15							
		60	14·00									
		80	13·77	34·98	26·25							
		100	13·51	34·95	26·27							
WS 730	7	0	17·57	35·41	25·71	—	—	N 50 V	100–0	1246	1248	
		10	17·26	35·29	25·69	—	—	N 70 B	88–0	1304	1324	KT
		20	16·91	35·24	25·74	—	—	N 100 B				
		30	14·48	35·04	26·14							
		40	14·11	35·04	26·21							
		50	14·01	35·02	26·22							
		60	13·93	35·01	26·23							
		80	13·81	34·99	26·24							
		100	13·43	34·97	26·31							
		150	13·17	34·96	26·34							
WS 731	7	0	17·72	35·34	25·62	—	—	N 50 V	100–0	1600	1602	
		10	17·62	35·35	25·65	—	—	N 70 B	117–0	1628	1648	KT
		20	17·58	35·35	25·66	—	—	N 100 B				
		30	17·56	35·35	25·67	—	—	N 100 B	320–115	1628	1657	Depth estimated
		40	17·53	35·35	25·68							
		50	14·89	34·97	26·00							
		60	14·43	34·97	26·10							
		80	13·61	34·97	26·27							
		100	13·26	34·96	26·32							
		150	12·69	34·96	26·44							
		200	12·00	34·91	26·54							
		300	10·99	34·82	26·66							
		400	9·50	34·71	26·84							
WS 732	7	0	16·51	35·20	25·80	—	—	N 50 V	100–0	2128	2130	
		10	16·51	35·16	25·77	—	—	N 70 B	97–0	2219	2239	KT
		20	16·49	35·16	25·77	—	—	N 100 B				
		30	16·44	35·16	25·78	—	—	N 100 B	255–95	2219	2249	Depth estimated
		40	16·15	35·16	25·85							
		50	16·02	35·16	25·88							
		60	16·01	35·16	25·88							
		80	14·63	34·98	26·06							
		100	13·82	34·96	26·21							
		150	13·06	34·93	26·34							
		200	12·30	34·92	26·49							
		300	10·90	34·81	26·67							
		400	9·19	34·69	26·86							
		600	6·83	34·58	27·13							
		800	5·55	34·53	27·26							
		1000	4·54	34·57	27·41							
WS 733	7	0	15·91	35·11	25·88	—	—	N 50 V	100–0	0615	0617	
		10	15·91	35·10	25·87	—	—	N 70 B	117–0	0635	0655	KT
		20	15·91	35·10	25·87	—	—	N 100 B				
		30	15·85	35·10	25·88	—	—	N 100 B	320–115	0635	0703	Depth estimated
		40	15·84	35·10	25·88							
		50	15·81	35·10	25·89							
		60	15·80	35·11	25·90							

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 733 *cont.*	12° 54·5′ S, 78° 43′ W	1931 21 viii											
WS 734	13° 16·5′ S, 79° 27·5′ W	21 viii	1247	4627	S	7–10	S	2	c	1013·5	16·7	15·0	mod. short S swell
WS 735	17° 47′ S, 77° 36′ W	23 viii	0845	—	SE	11–16	SE	4	c	1020·0	16·1	13·9	mod. av. SE swell
WS 736	22° 37·3′ S, 75° 27′ W	25 viii	0445	—	S × E	11–16	S × E	3	bc	1022·6	15·0	11·0	low long S × E swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 733 *cont.*	7	80	15·36	35·04	25·94							
		100	13·81	34·98	26·24							
		150	13·16	34·93	26·32							
		200	12·45	34·92	26·46							
		300	11·14	34·84	26·65							
		400	9·60	34·74	26·84							
		600	6·98	34·57	27·10							
		800	5·45	34·52	27·26							
		1000	4·52	34·52	27·37							
WS 734	8	0	17·16	35·47	25·86	—	—	**N 50 V**	100–0	1635	1637	
		10	17·09	35·34	25·77	—	—	**N 70 B**	165–0	1724	1744	KT
		20	17·05	35·34	25·78	—	—	**N 100 B**				
		30	17·04	35·34	25·78	—	—	**N 100 B**	430–165	1724	1754	Depth estimated
		40	17·03	35·34	25·79							
		50	17·02	35·34	25·79							
		60	17·01	35·34	25·79							
		80	16·92	35·28	25·76							
		100	15·04	35·03	26·00							
		150	13·21	34·95	26·33							
		200	12·35	34·86	26·43							
		300	11·07	34·83	26·65							
		400	9·07	34·67	26·87							
		600	7·01	34·54	27·08							
		800	5·64	34·51	27·23							
		1000	4·61	34·52	27·36							
		1500	3·24	34·57	27·54							
		2000	2·73	34·59	27·61							
		2500	2·16	34·66	27·71							
		3000	1·86	34·67	27·74							
		3500	1·83	34·68	27·75							
		4000	1·81	34·67	27·74							
WS 735	9	0	16·71	35·12	25·69	—	—	**N 50 V**	100–0	0934	0936	
		10	16·71	35·12	25·69	—	—	**N 70 B**	99–0	0953	1013	KT
		20	16·71	35·12	25·69	—	—	**N 100 B**				
		30	16·71	35·13	25·70	—	—	**N 100 B**	265–100	0953	1024	Depth estimated
		40	16·71	35·14	25·71							
		50	16·71	35·15	25·72							
		60	16·63	35·17	25·76							
		80	16·67	35·18	25·76							
		100	15·77	35·03	25·84							
		150	12·66	34·69	26·23							
		200	11·84	34·74	26·44							
		300	10·78	34·76	26·64							
		400	9·96	34·70	26·75							
		600	7·67	34·60	27·03							
		800	5·86	34·50	27·19							
		1000	4·80	34·51	27·33							
WS 736	11	0	16·35	34·79	25·53	—	—	**N 50 V**	100–0	**0556**	**0558**	
		10	16·37	34·79	25·52	—	—	**N 70 B**	155–0	0747	0807	KT
		20	16·38	34·79	25·52	—	—	**N 100 B**				
		30	16·37	34·79	25·52	—	—	**N 100 B**	400–155	0747	0820	Depth estimated
		40	16·37	34·79	25·52							
		50	16·36	34·78	25·51							
		60	16·31	34·77	25·52							
		80	16·29	34·76	25·51							
		100	16·22	34·76	25·53							
		150	11·70									
		200	11·85	34·82	26·50							
		300	10·45	34·71	26·67							
		400	8·74	34·69	26·93							
		600	6·47	34·58	27·18							
		800	5·96	34·48	27·17							
		1000	4·58	34·48	27·33							

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 736 *cont.*	22° 37·3′ S, 75° 27′ W	1931 25 viii											
WS 737	27° 23′ S, 73° 40′ W	27 viii	0100	—	SSE	17–21	S × E	4–5	b	1021·1	13·9	12·2	mod. av. to mod. long S × E swell
WS 738	32° 04·5′ S, 71° 36′ W	28 viii	1930	216	S	22–27	S	5	b	1020·8	11·9	10·4	mod. av. S swell
WS 739	32° 05′ S, 71° 47·5′ W	28–29 viii	2208	—	S	22–27	S	5	b	1020·7	11·9	10·6	mod. av. S swell
WS 740	33° 56′ S, 72° 15′ W	3 ix	2000	—	SW × S	11–16	SW × S	4	b	1020·6	11·9	10·6	heavy av. SW × S swell
WS 741	36° 00′ S, 73° 15·5′ W	4 ix	2000	—	SW	11–16	SW	4	b	1022·9	11·4	10·0	heavy short SW swell
WS 742	38° 22′ S, 73° 41′ W	5 ix	2000	—	NNW	4–6	NNW	2	o	1017·9	11·1	10·6	low short NNW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O_2 c.c. litre	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 736 *cont.*	11	1500	3·05	34·60	27·58							
		2000	2·28	34·62	27·68							
		2500	2·03	34·61	27·69							
		3000	1·89	34·67	27·74							
		3500	1·81									
		4000	1·76	34·67	27·75							
WS 737	13	0	14·58	34·48	25·68	—	—	**N 50 V**	100–0	**0200**	**0202**	
		10	14·59	34·48	25·68	—	—	**N 70 B**	150–0	**0225**	**0247**	Depth estimated
		20	14·59	34·48	25·68	—	—	**N 100 B**	390–150	**0225**	**0250**	Depth estimated
		30	14·54	34·48	25·69							
		40	14·51	34·48	25·70							
		50	14·38	34·43	25·69							
		60	13·51	34·37	25·82							
		80	12·62	34·31	25·95							
		100	12·19	34·30	26·03							
		150	10·88	34·41	26·36							
		200	11·00	34·67	26·54							
		300	9·97	34·65	26·70							
		400	8·99	34·60	26·82							
		600	5·97	34·42	27·11							
		800	4·99	34·42	27·23							
		1000	4·33	34·50	27·37							
WS 738	14	0	12·10	34·23	26·00	—	—	**N 50 V**	100–0	**2024**	**2026**	
		10	12·10	34·23	26·00	—	—	**N 70 B**	137–0	**2041**	**2101**	KT
		20	12·10	34·23	26·00	—	—	**N 100 B**				
		30	12·05	34·23	26·00							
		40	11·49	34·33	26·18							
		50	11·30	34·40	26·27							
		60	11·20	34·40	26·29							
		80	10·83	34·41	26·37							
		100	11·12	34·58	26·45							
		150	11·06	34·66	26·52							
		200	10·80	34·67	26·57							
WS 739	14	0	12·81	34·09	25·74	—	—	**N 50 V**	100–0	**2310**	**2312**	
		10	12·81	34·12	25·77	—	—	**N 70 B**	100–0	**2336**	**2356**	Depth estimated
		20	12·81	34·12	25·77	—	—	**N 100 B**				
		30	12·81	34·12	25·77	—	—	**N 100 B**	—	**2336**	**0006**	
		40	12·81	34·13	25·77							
		50	12·80	34·14	25·79							
		60	11·70	34·14	26·00							
		80	11·20	34·25	26·17							
		100	10·85	34·30	26·28							
		150	10·42	34·48	26·50							
		200	10·16	34·57	26·61							
		300	9·82	34·52	26·63							
		400	8·20	34·49	26·86							
WS 740	21	0	12·08	—	—	—	—	**N 50 V**	100–0	**2000**	**2002**	+4 hours
								N 70 B	132–0	**2041**	**2101**	KT
								N 100 B				
								N 100 B	340–132	**2041**	**2111**	Depth estimated
WS 741	22	0	11·95	—	—	—	—	**N 50 V**	100–0	**2004**	**2006**	
								N 70 B	135–0	**2029**	**2049**	Depth estimated
								N 100 B				
WS 742	23	0	11·27	—	—	—	—	**BTS**	58–47	**1755**	**1820**	Haul A
								BTS	47–35	**1845**	**1945**	Haul B
								N 50 V	35–0	**2010**	**2012**	
								N 70 B	23–0	**2033**	**2103**	KT
								N 100 B				

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
		1931											
WS 743	41° 05′ S, 74° 05′ W	8 ix	2000	170	SSW	7–10	SSW	3	b	1008·3	7·4	5·3	mod. av. SSW swell
WS 744	43° 40·5′ S, 75° 07·5′ W	9 ix	2000	—	SE	17–21	SE	4	o	1012·9	7·8	4·4	heavy av. SE swell
WS 745	46° 41′ S, 75° 45′ W	10 ix	2000	—	SSE	7–10	SSE	2	b	1025·8	7·2	4·4	mod. av. SSE swell
WS 746	53° 28′ S, 72° 44′ W	16 ix	0800	632	SE	7–10	SE	2	bc	1027·7	3·1	1·7	no swell
WS 747	53° 55·5′ S, 71° 16′ W	16 ix	1445	335	E	7–16	E	2–3	bc	1016·3	7·7	5·5	no swell
WS 748	53° 41·5′ S, 70° 55′ W	16 ix	1746	300	Lt airs	0–3	—	0	bc	1026·8	6·9	5·4	no swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS						BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	P. mg. atom m.³	O₂ c.c. litre	Gear	Depth (metres)	TIME From	TIME To	
WS 743	25	0	9·90	—	—	—	—	**N 50 V**	100–0	**2005**	**2007**	
								N 70 B **N 100 B**	146–0	**2036**	**2056**	KT
WS 744	27	0	9·34	—	—	—	—	**N 50 V**	100–0	**2005**	**2007**	
								N 70 B **N 100 B**	115–0	**2023**	**2043**	KT
WS 745	28	0	8·45	—	—	—	—	**N 50 V**	100–0	**2008**	**2010**	
								N 70 B **N 100 B**	100–0	**2021**	**2043**	Depth estimated
WS 746	4	0	5·59	30·26	23·88	—	—	**N 50 V**	100–0	0827	0829	
		600	8·41	33·30	25·89	—	—	**N 70 B** **N 100 B**	128–0	0853	0912	KT
WS 747	5	0	6·21	30·90	24·31	—	—	**N 50 V**	100–0	1513	1515	
		300	6·62	31·17	24·48	—	—	**N 70 B** **N 100 B**	74–0	1525	1545	KT
WS 748	5	0	6·12	30·87	24·30	—	—	**N 50 V**	100–0	**1810**	**1812**	
		300	6·37	31·13	24·48	—	—	**N 70 B**	100–0	**1834**	**1855**	Depth estimated
								NR	300(–0)	**1827**	**1915**	Depth estimated

R.R.S. 'WILLIAM SCORESBY'
TRAWLING SURVEY
STATIONS WS 749–882

18. ix. 1931—19. iv. 1932

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 749	52° 39·5′ S, 69° 53·5′ W	1931 18 ix	1052	40	Lt airs	0–3	—	0	bc	1020·5	5·3	4·7	no swell
WS 750	52° 12′ S, 67° 19′ W	19 ix	0030	95	NE	1–6	—	0	bc	1011·9	5·4	5·0	low long NE swell
WS 751	51° 50·5′ S, 65° 17·5′ W	19 ix	1200	145	N×E	7–10	NE	4–5	bc	1007·3	6·1	5·6	mod. av. NE swell
WS 752	51° 20′ S, 63° 17′ W	19–20 ix	2330	160	N×W	7–10	N×W	4–5	b	1012·3	6·1	5·0	mod. av. N×W swell
WS 753	50° 58·5′ S, 61° 04′ W	20 ix	1119	106	NNE	1–6	NW	2	c	1014·5	7·1	5·6	mod. short NW swell
WS 754	51° 09·5′ S, 58° 54′ W	20 ix	2230	111	NNE	17–27	NNE	4	o	1010·1	4·6	4·3	mod. long N swell
WS 755	51° 39′ S, 57° 39′ W	21 ix	0740	—	N	17–21	N	4	o	1016·5	5·6	3·9	mod. short N swell
WS 756	From 50° 53′ S, 60° 00′ W	10 x	0700	119 bl.G. gn.M.S	N×E	11–16	NE	3	c	1023·5	4·2	2·8	mod. short N swell
	to 50° 56·3′ S, 59° 56′ W		1130										
	to 50° 59·5′ S, 59° 52′ W		1545	90	NNE	17–21	NNE	4–5	o	1019·5	4·4	3·3	mod. long NNE swell
WS 757	49° 56′ S, 60° 33′ W	11 x	1100	166	N×W	7–10	N	4	c	1019·1	6·9	6·4	mod. av. N swell
WS 758	48° 32′ S, 61° 19′ W	12 x	0000	112 R	N	7–10	N	3	of	1013·9	6·0	5·6	mod. av. N swell
WS 759	47° 08′ S, 62° 06′ W	12 x	1605	135	NNE	17–21	NNE	4–5	bc	996·1	8·9	7·8	mod. av. NNE swell
WS 760	45° 40′ S, 62° 26′ W	13 x	0600	110	SW	17–21	SW	5–9	o	1007·7	6·7	6·1	heavy av. conf. swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σ_t	Gear	Depth (metres)	TIME From	TIME To	
WS 749	6	0	3·52	31·47	25·06	**N 50 V**	40–0	1105	1107	+4 hours
		40	3·49	31·55	25·11	**N 70 B**	25–0	1139	1159	Depth estimated
						N 100 B				
						NR	40(–0)	1139	1206	
WS 750	7	0	4·77	33·09	26·21	**N 50 V**	90–0	**0104**	**0106**	
		90	4·79	33·10	26·21	**N 100 B**	80–0	**0137**	**0157**	KT
						NR	95(–0)	**0137**	**0207**	
WS 751	7	0	5·01	33·23	26·30	**N 50 V**	100–0	1230	1232	
		140	5·00	33·26	26·32	**N 70 B**	102–0	1300	1317	KT
						N 100 B				
						NR	145(–0)	1300	1335	
WS 752	8	0	5·13	33·49	26·49	**N 50 V**	100–0	**2357**	**2359**	
		155	5·20	33·52	26·51	**N 70 B**	77–0	**0031**	**0051**	KT
						N 100 B				
						NR	160(–0)	**0031**	**0110**	
WS 753	8	0	5·00	33·78	26·74	**N 50 V**	102–0	1119	1121	
		100	4·92	33·79	26·76	**N 70 B**	73–0	1201	1221	KT
						N 100 B				
						NR	106(–0)	1201	1231	
WS 754	9	0	3·98	33·77	26·83	**N 50 V**	100–0	**2252**	**2254**	
		100	3·79	33·77	26·85	**N 70 B**	82–0	**2311**	**2331**	KT
						N 100 B				
						NR	111(–0)	**2311**	**2342**	
WS 755	10	0	4·25	33·78	26·82	**N 50 V**	70–0	0808	0810	
		70	4·17	33·78	26·83	**N 70 B**	50–0	0825	0845	Depth estimated
						N 100 B				
						NR	75(–0)	0825	0853	
WS 756	28	0	4·32	33·75	26·78	**N 50 V**	100–0	0744	0746	+3 hours
		110	4·02	33·70	26·77	**DC**	119	0800		
						N 70 B	75–0	0845	0905	KT. **N 100 B** did not fish properly
						N 100 B				
	28	—	—	—	—	**NR**	119(–0)	0845	0920	
						OTC	119–104	1028	1130	Haul A
						OTC	104–90	1435	1545	Haul B. **N 4-T** did not fish properly
						N 7-T				
						N 4-T				
						NCS-T				
WS 757	29	0	5·40	33·83	26·73	**N 50 V**	100–0	1126	1128	
		160	5·27	33·83	26·75	**N 70 B**	139–0	1200	1220	KT
						N 100 B				
						NR	166(–0)	1200	1237	
WS 758	1	0	5·72	33·69	26·57	**N 50 V**	100–0	**0014**	**0016**	
		110	5·30	33·76	26·68	**N 70 B**	94–0	**0054**	**0114**	KT
						N 100 B				
						NR	112(–0)	**0054**	**0130**	
WS 759	1	0	6·61	33·61	26·40	**N 70 B**	88–0	1658	1718	KT
		130	6·06	33·74	26·57	**N 100 B**				
						NR	135(–0)	1658	1730	
						N 50 V	100–0	1744	1746	
WS 760	2	0	7·33	33·38	26·12	**N 50 V**	100–0	0620	0622	
		110	6·21	33·56	26·42	**N 70 B**	62–0	0715	0735	KT. **N 70 B** did not fish properly
						N 100 B				
						NR	110(–0)	0715	0750	

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 761	44° 22′ S, 63° 02′ W	1931 13 x	1800	97 gn.S.M	SW × S	11–16	SW × S	4	bc	1011·3	8·3	6·7	mod. av. SW × S swell
WS 762	From 43° 48·5′ S, 65° 00′ W	16 x	0615	68 gy.S.M	W × S	11–16	W × S	2	bc	1005·6	10·0	6·1	low av. W × S swell
	to 43° 51·5′ S, 65° 03·7′ W		0830										
	to 43° 48·5′ S, 65° 06·5′ W		1010	66									
WS 763	From 44° 14·5′ S, 63° 30′ W	16 x	1815	86 M.S	SW	4–6	SW	3	b	1011·2	9·4	6·7	low long SW swell
	to 44° 13·5′ S, 63° 26′ W		2030	82									
WS 764	From 44° 40′ S, 62° 00′ W	17 x	0605	106 f.gn.S	SW × W	7–10	SW × W	3	b	1010·3	9·4	6·7	mod. short SW × W swell
	to 44° 36·5′ S, 61° 57′ W		0830	110									
	to 44° 41′ S, 61° 52′ W		1015	104									
WS 765	From 45° 06′ S, 60° 30′ W	17 x	1730	113 br.gn. M.S	W	7–10	W	3	b	1015·0	7·8	5·8	mod. av. SW swell
	to 45° 08′ S, 60° 26·5′ W		1950	119									
WS 766	45° 13′ S, 59° 56·5′ W	18–19 x	1800	545 f.d.gy.S	SW × W	17–21	SW × W	4	bcqp	1013·0	5·0	4·2	mod. av. SW × W swell
	44° 58′ S, 60° 05·5′ W		1245	—	S	11–16	S	4	b	1024·9	6·7	4·4	mod. av. to mod. long S swell
WS 767	45° 12′ S, 61° 41′ W	19 x	2215	98	W	4–6	W	2	b	1016·4	7·8	6·1	mod. short SSW swell
WS 768	45° 31′ S, 63° 23′ W	20 x	0932	108 gn.M	NW	7–10	NW × N	2	bc	1020·7	8·3	7·3	mod. short NW swell
WS 769	45° 45′ S, 64° 53′ W	20 x	1845	99 gy.M	NW	1–3	NW	0–1	bc	1010·6	11·1	9·2	low long NW swell
WS 770	46° 03′ S, 66° 34′ W	21 x	0445	95 b.gy. Cy	WNW	7–10	W	3	b	1002·5	10·6	9·4	low long W swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S ‰	σt	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 761	2	0	8·17	33·42	26·04	N 50 V	95–0	1810	1812	
		95	6·43	33·69	26·48	N 70 B	73–0	1840	1900	KT
						N 100 B				
						NR	97(–0)	1840	1918	
WS 762	5	0	8·60	33·42	25·97	N 50 V	50–0	0630	0632	
		65	8·60	33·44	25·98	DC	68	0638	0645	
						OTC				
						N 7-T	68–66	0720	0830	Haul A
						N 4-T				
						NCS-T				
						OTC				
						N 7-T	68–66	0910	1010	Haul B
						NCS-T				
WS 763	5	0	8·44	33·38	25·96	N 50 V	75–0	1833	1835	
		80	6·59	33·62	26·41	DC	86	1854	1910	
						OTC				
						N 7-T	86–82	1925	2030	
						NCS-T				
WS 764	6	0	7·50	33·54	26·22	N 50 V	100–0	0630	0632	
		100	6·09	33·64	26·49	DC	106	0642	0655	
						OTC				
						N 7-T	106–110	0720	0830	Haul A
						N 4-T				
						NCS-T				
						OTC				
						N 7-T	110–104	0915	1015	Haul B
						N 4-T				
						NCS-T				
WS 765	6	0	6·78	33·70	26·45	N 50 V	100–0	1753	1755	
		110	5·52	33·82	26·71	DC	113	1800	1815	
						OTC				
						N 7-T	113–119	1845	1950	
						N 4-T				
						NCS-T				
WS 766	7	0	6·35	33·78	26·57	N 50 V	100–0	1833	1835	
		500	4·32	34·13	27·08	DC	545	1845	1920	
	8	—	—	—	—	OTC				
						N 7-T	545	2010	2040	Trawl badly torn, empty
						N 4-T				
						NCS-T				
						N 70 B	128–0	1313	1333	KT
						N 100 B				
WS 767	8	0	7·28	33·62	26·32	N 50 V	98–0	2240	2242	
						N 70 B	53–0	2317	2327	KT
						N 100 B				
						NR	98(–0)	2317	2348	
WS 768	9	0	7·69	33·31	26·02	N 50 V	100–0	0953	0955	
		100	6·35	33·50	26·35	N 70 B	51–0	1015	1035	KT
						N 100 B				
						NR	108(–0)	1015	1045	
WS 769	9	0	8·41	33·17	25·80	N 50 V	96–0	1905	1907	
		90	7·22	33·16	25·97	N 70 B	58–0	1925	1946	KT
						N 100 B				
						NR	99(–0)	1925	2000	
WS 770	10	0	8·90	33·34	25·86	N 50 V	90–0	0450	0452	
		90	7·51	33·32	26·05	N 70 B	57–0	0515	0535	KT
						N 100 B				
						NR	95(–0)	0515	0555	Completely full of mud

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 771	From 42° 40′ S, 60° 32′ W	1931 29 x	1615	90 d.gn.S	E	1–6	E	1	ofe	1010·0	11·7	11·1	low av. E swell
	to 42° 43·5′ S, 60° 30′ W		1830	90									
WS 772	From 45° 13′ S, 60° 00′ W	30 x	1500	309 gy.S	NW	1–6	—	0	f	1010·5	8·1	7·2	mod. low long to short NW swell
	to 45° 13·8 S, 60° 00·5′ W		1645	163									
WS 773	From 47° 27′ S, 60° 49′ W	31 x	1225	291 gn.S.M	WNW	11–16	W × N	4	bc	1001·0	9·2	7·5	mod. av. W × N swell
	to 47° 29′ S, 60° 53′ W		1433	298									
WS 774	From 47° 09′ S, 62° 00′ W	1 xi	1625	139 d.gn. S.M	W × S	11–16	WSW	3	bc	996·6	9·8	7·8	mod. short WSW swell
	to 47° 07′ S, 62° 04′ W		1830	144									
WS 775	From 46° 44·5′ S, 63° 30′ W	2 xi	1500	115 G.f. gy.S	W × S	11–16	W	3–4	c	990·6	10·6	7·9	mod. long W swell
	to 46° 45′ S, 63° 36′ W		1720	110									
WS 776	From 46° 19′ S, 65° 00′ W	3 xi	0510	110 gy.M.S	NNE	4–6	NNE	0–1	b	987·9	9·7	7·9	low av. conf. swell
	to 46° 17·5′ S, 65° 04·5′ W		0725	99 gy.M.S									
WS 777	From 45° 56′ S, 66° 24′ W	3 xi	1700	98 b.gy. Cy.M	SW	11–16	SW	4	o	993·3	9·7	6·7	mod. short SW swell
	to 45° 58′ S, 66° 27′ W		1930	99 gn.gy. St									
WS 778	47° 33′ S, 65° 00′ W	4 xi	1145	77	WSW	11–16	S	4	bc	1000·8	10·0	6·1	mod. av. S swell
WS 779	47° 58′ S, 63° 30′ W	4 xi	2000	110	NW	7–10	NW	4	bc	992·2	8·6	6·6	mod. av. SSE swell
WS 780	48° 22′ S, 62° 00′ W	5 xi	0430	148	W × S	17–21	conf.	5	oq	981·9	6·7	5·1	mod. long SW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 771	18	0	10·11	33·59	25·86	**N 50 V**	90–0	1623	1625	
		90	6·27	33·78	26·58	**DC**	90	1630	1652	
						OTC N 7-T N 4-T NCS-T	90–90	1730	1830	
WS 772	19	0	7·91	33·76	26·34	**N 50 V**	100–0	1528	1530	
		300	4·59	34·07	27·01	**DC**	309	1534		
						OTC N 7-T N 4-T NCS-T	309–163	1630	1645	Trawl hitched on bottom but came up intact
WS 773	20	0	6·82	33·78	26·51	**N 50 V**	100–0	1246	1248	
		290	4·77	34·07	26·99	**DC**	291	1315	1325	
						OTC N 7-T N 4-T NCS-T	291–298	1423	1433	
WS 774	22	0	8·00	33·72	26·29	**N 50 V**	100–0	1644	1646	
		130	6·23	33·73	26·54	**DC**	139	1651	1710	
						OTC N 7-T N 4-T NCS-T	139–144	1730	1830	
WS 775	22	0	8·00	33·27	25·93	**N 50 V**	100–0	1515	1517	
		110	6·18	33·37	26·26	**DC**	115	1525	1545	
						OTC N 7-T N 4-T NCS-T	115–110	1620	1720	
WS 776	23	0	8·50	33·12	25·74	**N 50 V**	100–0	0535	0537	
		105	7·58	33·18	25·93	**DC**	110	0550	0605	
						OTC N 7-T N 4-T NCS-T	110–99	0625	0725	
WS 777	23	0	9·75	33·34	25·72	**N 50 V**	95–0	1715	1717	
		95	7·53	33·32	26·05	**DC**	98	1721	1740	
						OTC N 7-T N 4-T NCS-T	98–99	1830	**1930**	1 cwt. fossiliferous stones taken in trawl
WS 778	24	0	6·84	33·18	26·03	**N 50 V**	77–0	1150	1152	
		70	6·78	33·20	26·06	**N 70 B N 100 B**	29–0	1223	1243	KT
						NR	77(–0)	1223	1253	
WS 779	24	0	7·18	33·59	26·31	**N 50 V**	100–0	**2010**	**2012**	
		105	6·54	33·60	26·40	**N 70 B N 100 B**	71–0	**2039**	**2059 2108**	KT. **N 100 B** slipped on hauling
						NR	110(–0)	**2039**	**2109**	
WS 780	25	0	6·67	33·64	26·41	**N 50 V**	100–0	0430	0432	
		140	5·51	33·69	26·60	**N 70 B N 100 B**	93–0	0513	0533	KT
						NR	148(–0)	0513	0540	

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 781	From 50° 29′ S, 58° 52′ W	1931 6 xi	1602	148 d.gn. S.M	W	11–16	W	3	cqrs	994·9	2·8	2·2	mod. short W swell
	to 50° 31′ S, 58° 48′ W		1920										
WS 782	From 50° 30′ S, 58° 19′ W	4 xii	0434	141 gn.S.R	NW	11–21	NW	4	c	1007·4	7·8	6·7	mod. short NNW swell
	to 50° 28·5′ S, 58° 23·5′ W		0825										
	to 50° 27′ S, 58° 31′ W		1127	146	NW	17–21	NW	5	bc	1006·9	8·9	7·8	mod. long NW swell
WS 783	50° 03·5′ S, 60° 08′ W	5 xii	0405	161	SW	4–6	W	1	ce	1011·0	8·9	7·8	low av. W swell
	50° 08′ S, 59° 50′ W		0505	R.St.Sh									
	50° 07·5′ S, 59° 53′ W		0540	161 R.St									
	50° 03·5′ S, 60° 08′ W		0705	157 R.M.S	—	0–3	—	0	b	1013·7	10·0	8·3	low av. to low long N swell
	From 50° 03·5′ S, 60° 08′ W		0735	157									
	to 50° 02′ S, 60° 12′ W		0910										
	to 50° 03·5′ S, 60° 16′ W		1115	165	N	4–6	NW	2	b	1012·2	8·3	7·8	low long NW swell
WS 784	From 49° 48·5′ S, 61° 03′ W	5 xii	1606	170 d.gn. S.R	NNW	7–16	NW	3	bc	1010·6	8·9	7·8	mod. short N × W swell
	to 49° 47′ S, 61° 07′ W		1835	164									
WS 785	From 49° 27′ S, 62° 32′ W	6 xii	0820	113	N	17–21	N	4–5	oc	995·2	10·6	10·0	mod. av. to mod. long N swell
			0910	150 d.gn.S									
	to 49° 26′ S, 62° 36′ W		1110	147									
			1200	—	N	17–21	N	4	oc	993·0	10·6	10·0	mod. av. N swell
	to 49° 24·5′ S, 62° 39′ W		1250	147									
	to 49° 23′ S, 62° 43·5′ W		1430	147									
WS 786	From 49° 07′ S, 63° 55′ W	7 xii	0330	134 d.S.R	SW	4–6	W	2	b	1006·9	8·6	7·2	low long W × S swell
	to 49° 06′ S, 63° 59′ W		0630	119									
WS 787	From 48° 44′ S, 65° 24·5′ W	7 xii	1453	106 c.br. sk.S	N	7–10	N × W	3	bc	1009·5	11·1	8·9	mod. short N × W swell
	to 48° 48′ S, 65° 25′ W		1715	110									

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S°/oo	σt	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 781	26	0	5·58	33·78	26·67	N 50 V	100–0	1623	1626	
		140	4·78	33·88	26·84	DC	148	1649	1700	
						OTC N 7-T N 4-T NCS-T	148	1800	1920	
WS 782	24	0	7·32	33·89	26·52	N 50 V	100–0	0529	0532	
		135	5·14	33·96	26·86	DC	141	0555	0604	
	24	—	—	—	—	OTC N 7-T N 4-T NCS-T	141–146	0725	0825	Haul A
						OTC N 7-T NCS-T	141–146	1020	1120	Haul B
WS 783	24	0	8·04	33·86	26·39	N 50 V	100–0	0445	0447	Net torn
		155	4·89	33·88	26·83	DC	161	0505	0525	Haul I
						DC	161	0540	0603	Haul II
						DC	157	0705	0735	Haul III
	24	—	—	—	—	OTC N 7-T N 4-T NCS-T	157–165	0805	0910	Haul A
	25	—	—	—	—	OTC N 7-T N 4-T NCS-T	165–0	1015	1115	Haul B. Trawl hauled obliquely
WS 784	25	0	8·05	33·69	26·26	N 50 V	100–0	1632	1635	
		165	4·82	33·86	26·81	DC	170	1645	1700	
						OTC N 7-T N 4-T NCS-T	170–164	1735	1835	
WS 785	26	0	8·78	33·59	26·08	N 50 V	100–0	0910	0912	
		110	5·72	33·60	26·51	DC	150	0925	0950	
	27	—	—	—	—	OTC N 7-T N 4-T NCS-T	150–147	1010	1110	Haul A
						OTC N 7-T N 4-T NCS-T	150–147	1150	1250	Haul B
						OTC N 7-T N 4-T NCS-T	150–147	1330	1430	Haul C
WS 786	27	0	8·39	33·50	26·06	N 50 V	100–0	0425	0427	
		130	6·34	33·53	26·37	DC	134	0435	0455	
						OTC N 7-T N 4-T NCS-T	134–119	0520	0630	
WS 787	28	0	9·56	33·53	25·90	N 50 V	100–0	1508	1510	
		105	7·35	33·55	26·25	DC	106	1520	1540	
						OTC N 7-T N 4-T NCS-T	106–110	1615	1715	

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
		1931											
WS 788	45° 05′ S, 65° 00′ W	13 xii	1520	82 sk.gy. M.S.G	Lt airs	0	—	0	bc	1014·8	19·4	—	low av. W swell
	From 45° 06·5′ S, 64° 56′ W		1755										
	to 45° 07·5′ S, 64° 52′ W		1855	88									
WS 789	From 45° 17′ S, 64° 22′ W	13 xii	2140	95 sk.gy. gn.M	NE	1–10	NNE	2	cr	1005·6	13·9	13·6	low long NNE swell
	to 45° 18·5′ S, 64° 18′ W		2343	93 sk.gy.S.M									
WS 790	From 45° 28·3′ S, 63° 42·3′ W	14 xii	0532	99 gn.gy. S.M	—	0	—	0	bc	1007·4	13·9	12·2	low av. to low long N swell
	to 45° 29·5′ S, 63° 39′ W		0730										
	to 45° 33·5′ S, 63° 23′ W		1240	101	NNW	1–6	—	0	bc	1008·1	15·6	14·4	low av. N swell
WS 791	From 45° 38′ S, 62° 57′ W	14 xii	1446	101	N×W	4–6	N×W	2	c	1005·9	15·6	14·8	low long N swell
			1528	97 gn.S									
	to 45° 39·5′ S, 62° 53′ W		1700	95									
	to 45° 44′ S, 62° 37′ W		2350	101	NW	7–16	NNW	4	c	998·0	15·6	13·3	mod. av. NNW swell
WS 792	From 45° 49′ S, 62° 23′ W	15 xii	0140	102 d.gn. S.R	NW	7–10	NW	3	c	996·7	15·3	13·3	low long NW×N swell
	to 45° 50′ S, 62° 18·5′ W		0350	106									
			0430	106	WSW	7–16	NW	2–3	c	997·2	16·1	13·9	low long to mod. short W swell
	to 45° 54·5′ S, 62° 04′ W		0850	112 gn.S.M	W×N	7–16	WNW	3	c	996·0	14·7	12·8	low long NW swell
WS 793	45° 58′ S, 61° 42′ W	15 xii	1100	110 d.gn.S	W	7–10	W×S	2	c	996·0	15·8	13·8	mod. short W×S swell
	From 45° 52·3′ S, 61° 37′ W	16 xii	0200	108 R	WSW	11–16	W	3	b	997·9	15·6	12·2	mod. av. W swell
	to 45° 53·8′ S, 61° 33′ W		0350	111									
WS 794	From 46° 11·8′ S, 61° 01′ W	17 xii	0732	123	W	17–21	W	4–5	b	1003·0	13·3	8·9	mod. av. to mod. long W swell
	to 46° 13·5′ S, 60° 57·5′ W		0950	126									
WS 795	From 46° 14′ S, 60° 24′ W	18 xii	0905	157 S.R	SSW	11–16	S	4	b	1017·5	10·3	8·3	mod. av. S swell
	to 46° 16′ S, 60° 21′ W		1211	161									
WS 796	From 47° 50·3′ S, 63° 40·5′ W	19 xii	1035	106 c.br.sk.S	SSW	11–21	SSW	3	bc	1003·4	10·6	8·9	mod. av. SSW swell
	to 47° 49′ S, 63° 44·5′ W		1300	113									
	From 47° 51′ S, 63° 43′ W	21 xii	0345	108	S	1–3	—	0	bc	1014·0	8·9	6·4	mod. short S swell
	to 47° 56′ S, 63° 22′ W		0750	112									

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S °/₀₀	σ_t	Gear	Depth (metres)	TIME From	TIME To	
WS 788	3	0	13·45	33·33	25·03	N 50 V	80–0	1538	1540	
		80	9·70	33·33	25·72	DC	82	1543	1555	
						OTC N 7-T N 4-T NCS-T	82–88	1755	1855	
WS 789	3	0	13·78	33·29	24·93	N 50 V	90–0	2159	2201	
		90	7·12	33·35	26·13	OTC N 7-T N 4-T NCS-T	95–93	2227	2343	
WS 790	3	0	13·11	33·24	25·03	N 50 V	100–0	0544	0546	
		95	7·14	33·48	26·22	DC	99	0550	0605	
	4	—	—	—	—	OTC N 7-T N 4-T NCS-T	99–101	0625	0730	Haul A
						OTC N-T	99–101	0835	1240	Haul B
WS 791	4	0	13·62	33·38	25·03	N 50 V	95–0	1517	1520	
		95	6·52	33·53	26·35	DC	97	1528	1540	
	5	—	—	—	—	OTC N 7-T N 4-T NCS-T	97–95	1600	1700	Haul A
						OTC N-T	95–101	1950	2350	Haul B
WS 792	6	0	13·10	33·35	25·12	N 50 V	100–0	0207	0209	
		100	6·43	33·56	26·39	DC	102	0215	0230	
	6	—	—	—	—	OTC N 7-T N 4-T NCS-T	102–106	0250	0350	Haul A
	6	—	—	—	—	OTC N 7-T N 4-T NCS-T	106–112	0450	0850	Haul B
WS 793	6	0	13·15	33·51	25·23	N 50 V	100–0	1119	1121	
		100	6·52	33·69	26·47	DC	110	1125	1140	
	7	—	—	—	—	OTC N 7-T N 4-T NCS-T	108–111	0250	0350	
WS 794	8	0	11·20	33·69	25·74	N 50 V	100–0	0756	0758	
		123	6·07	33·74	26·57	OTC N 7-T NCS-T	123–126	0850	0950	
WS 795	9	0	9·28	33·90	26·23	N 50 V	100–0	0935	0938	
		150	4·83	34·03	26·95	DC	157	1020	1050	
						OTC N 7-T N 4-T NCS-T	157–161	1111	1211	
WS 796	10	0	14·41	33·63	25·07	N 50 V	100–0	1055	1058	Position re-visited on 21 xii when Haul B was taken
		100	7·33	33·64	26·32	DC	106	1110	1130	
	12	—	—	—	—	OTC N 7-T N 4-T NCS-T	106–113	1200	1300	Haul A

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
		1931											
WS 796 *cont.*	From 47° 51′ S, 63° 43′ W to 47° 56′ S, 63° 22′ W	21 xii											
WS 797	47° 45·3′ S, 64° 10·5′ W	19 xii	1705	117 St	SW	17–21	S×W	5	b	1006·2	11·7	8·3	mod. long SSW swell
	From 47° 44′ S, 64° 22′ W	20 xii	1635	115	SSW	11–21	SSW	4	bc	1013·2	12·2	8·3	mod. long SSW swell
	to 47° 45·2′ S, 64° 18′ W		1812	111									
	to 47° 50·3′ S, 63° 57′ W		2355	113	S	4–6	S	2	b	1014·2	8·3	7·2	mod. av. S swell
WS 798	From 47° 31·5′ S, 65° 02′ W	20 xii	1040	49 P.Sh.S	SW	7–16	SW	3	b	1012·2	10·0	7·6	mod. av. SW swell
	to 47° 32·5′ S, 64° 58′ W		1242	66									
WS 799	From 48° 03·5′ S, 62° 50·3′ W	21 xii	1100	141 d.gn.S	S	1–3	S	1	b	1012·2	10·3	6·9	low long S swell
	to 48° 05′ S, 62° 46′ W		1307	137									
	to 48° 10′ S, 62° 31′ W		1745	139	NW	4–10	S	2	b	1010·6	10·0	6·7	low av. SSE swell
WS 800	From 48° 15′ S, 62° 11·8′ W	21–22 xii	2015	139 d.S.Sh	NW	7–10	NW	3	bc	1008·9	10·0	7·8	mod. short W swell
	to 48° 16·5′ S, 62° 08′ W		2210	137									
			2400	—	NW	11–16	NW	2	c	1008·0	10·0	7·8	mod. short NW swell
	to 48° 21·5′ S, 61° 48′ W		0250	139									
WS 801	From 48° 25·5′ S, 61° 30′ W	22 xii	0455	165 d.S	NW	7–16	NW	3	c	1004·6	10·0	8·9	mod. short NW swell
	to 48° 27′ S, 61° 26′ W		0655	165									
		1932											
WS 802	50° 46′ S, 61° 20′ W	3 i	1408	137 gn.S.Sh	SW×W	17–27	SW	4	bcq	1003·0	10·0	7·8	mod. av. SW swell
	From 50° 47′ S, 61° 20′ W	5 i	1250	128	NNW	7–10	NNW	3	bc	1010·4	11·1	10·0	mod. short NNW swell
	to 50° 44·5′ S, 61° 24′ W		1447	132									
	to 50° 43′ S, 61° 28′ W		1630	139									
WS 803	From 50° 34·5′ S, 62° 03·5′ W	5 i	2050	174 St.c.d.S	NNW	7–10	NNW	1	bc	1004·1	12·8	11·4	mod. short NNW swell
	to 50° 33′ S, 62° 07·5′ W		2345	187									

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 796 *cont.*	12					**OTC N 7-T N 4-T NCS-T**	108–112	**0350**	0750	Haul B
WS 797	10	0	10·37	33·52	25·76	**N 50 V**	100–0	1715	1717	Position re-visited on 20 xii when
		110	7·57	33·53	26·20	**DC**	117	1720	1735	Hauls B and C were taken
	11	—	—	—	—	**NCS-T**	117	1800	1812	Haul A
	11	—	—	—	—	**OTC N 7-T N 4-T NCS-T**	115–111	1712	1812	Haul B
						OTC N 7-T N 4-T NCS-T	111–113	2000	**2355**	Haul C
WS 798	11	0	9·05	33·23	25·76	**N 50 V**	49–0	1056	1058	
		48	8·89	33·23	25·78	**DC**	49	1105	1115	
						OTC N 7-T N 4-T NCS-T	49–66	1142	1242	
WS 799	12	0	10·97	33·63	25·74	**N 50 V**	100–0	1118	1120	
		135	6·74	33·69	26·44	**DC**	141	1125	1145	
	12	—	—	—	—	**OTC N 7-T N 4-T NCS-T**	141–137	1207	1307	Haul A
						OTC N 7-T N 4-T NCS-T	137–139	1345	1745	Haul B
						NH	0	1700		
WS 800	13	0	9·90	33·68	25·96	**N 50 V**	100–0	2030	2032	
		135	5·80	33·68	26·55	**DC**	139	2030	2055	
	13	—	—	—	—	**OTC N 7-T N 4-T NCS-T**	139–137	2110	**2210**	Haul A
						OTC N 7-T N 4-T NCS-T	137–139	**2250**	**0250**	Haul B
WS 801	13	0	9·33	33·69	26·06	**N 50 V**	100–0	**0514**	**0517**	
		160	5·14	33·80	26·73	**DC**	165	0527		
						OTC N 4-T NCS-T	165–165	0555	0655	
WS 802	25	0	7·83	33·76	26·35	**N 50 V**	100–0	1443	1445	Position re-visited on 5 i 32 when
		130	5·97	33·80	26·63	**DC**	137	1530	1550	hauls A and B were taken
	27	—	—	—	—	**OTC N 4-T NCS-T**	128–132	1335	1447	Haul A
						OTC N 7-T N 4-T NCS-T	132–139	1530	1630	Haul B
WS 803	27	0	10·09	33·63	25·90	**N 50 V**	100–0	**2057**	**2059**	
		170	5·26	33·80	26·72	**DC**	174	**2115**	**2140**	

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 803 *cont.*	From 50° 34·5′ S, 62° 03·5′ W to 50° 33′ S, 62° 07·5′ W	1932 5 i											
WS 804	From 50° 23·5′ S, 62° 47′ W	6 i	0416	150 G.St.S	N × W	4–10	NNW	2	bc	992·0	11·7	10·6	low long to mod. short NNW swell
	to 50° 22′ S, 62° 51′ W		0647	143									
			0800	—	WNW	7–10	WNW	3	bc	992·7	13·9	10·6	low long WNW swell
	to 50° 20·5′ S, 62° 55′ W		0845	150									
WS 805	From 50° 11′ S, 63° 27′ W	6 i	1530	150 c.d. sk.S	WSW	11–16	SW × W	4	bc	1001·4	11·9	9·3	mod. av. SW × W swell
	to 50° 09·5′ S, 63° 31′ W		1745	148									
WS 806	From 50° 04′ S, 64° 19′ W	7 i	0500	130 d.gn. sk.S.Sh	NW	4–10	WNW	2–3	b	1012·2	10·0	8·3	mod. av. W swell
	to 50° 03′ S, 64° 23′ W		0715	123									
WS 807	From 49° 51′ S, 65° 01′ W	7 i	1146	124 d.S	N	11–16	N × W	3	c	1006·7	12·2	9·2	mod. short N × W swell
	to 49° 50′ S, 65° 05′ W		1340	126									
WS 808	From 49° 41′ S, 65° 40′ W	8 i	0450	110 br.gn.S	NW	11–21	NW	3–4	o	988·6	13·3	10·0	mod. av. WNW swell
	to 49° 39·5′ S, 65° 44′ W		0735	106									
WS 809	From 49° 29′ S, 66° 27′ W	8 i	1330	108 br.sk.S	SW	7–10	SW	3	bc	997·1	13·2	10·6	mod. short SW swell
	to 49° 27·5′ S, 66° 31′ W		1555	104									
	to 49° 32·5′ S, 66° 51·5′ W		2035	101	SW	11–16	SW	4	b	1000·2	13·3	10·0	mod. av. SW swell
WS 810	From 49° 15′ S, 67° 08′ W	9 i	0015	95 b.gy. S.M	SW	11–16	SW	4	b	1005·9	12·1	10·6	mod. av. SSW swell
	to 49° 19′ S, 67° 08′ W		0255	97									
WS 811	From 51° 27′ S, 68° 03′ W	10 i	0540	99 S.St	Lt airs	0–3	—	0–1	bc	1009·2	10·0	8·3	low long to mod. short SE swell
	to 51° 28·5′ S, 68° 00′ W		0801	99									
	From 51° 22′ S, 68° 03′ W	12 i	1935	97	WSW	11–16	W × S	3–4	bc	998·0	13·3	8·9	mod. short W swell
	to 51° 27′ S, 67° 43′ W		0000	99									

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 803 *cont.*	27					**OTC** **N 7-T** **NCS-T**	174–187	2245	2345	
WS 804	28	0	10·11	33·51	25·80	**N 50 V**	100–0	0445	0447	
		147	5·70	33·52	26·45	**DC**	150	0450	0513	
	28	—	—	—	—	**OTC** **N 7-T** **NCS-T**	150–143	0547	0647	Haul A
						OTC **N 7-T** **N 4-T** **NCS-T**	143–150	0745	0845	Haul B
WS 805	28	0	10·69	33·38	25·59	**N 50 V**	100–0	1556	1558	
		145	5·73	33·43	26·38	**DC**	150	1605	1630	
						OTC **N 7-T** **N 4-T** **NCS-T**	150–148	1645	1745	
WS 806	29	0	11·01	33·23	25·43	**N 50 V**	100–0	0520	0522	
		125	6·25	33·23	26·16	**DC**	130	0530	0545	
						OTC **N 7-T** **N 4-T** **NCS-T**	130–123	0615	0715	
WS 807	0	0	11·11	33·29	25·45	**N 50 V**	100–0	1201	1203	
		120	6·38	33·30	26·18	**DC**	124	1208	1223	
						OTC **N 7-T** **N 4-T** **NCS-T**	124–126	1240	1340	Catch lost but similar to **NCS-T** at **WS 806**
WS 808	0	0	11·21	33·31	25·45	**N 50 V**	100–0	0511	0513	
		109	7·16	33·36	26·13	**DC**	110	0530	0600	
						OTC **N 7-T** **N 4-T** **NCS-T**	110–106	0630	0735	Net badly torn
WS 809	1	0	11·29	33·40	25·50	**N 50 V**	100–0	1344	1346	
		100	7·54	33·41	26·12	**DC**	108	1350	1410	
	1	—	—	—	—	**OTC** **N 7-T** **N 4-T** **NCS-T**	108–104	1450	1555	Haul A
						OTC	104–101	1635	2035	Haul B
WS 810	1	0	10·12	33·02	25·41	**N 50 V**	90–0	0051	0053	
		90	8·07	33·14	25·83	**DC**	95	0115	0135	
						OTC **N 7-T** **NCS-T**	95–97	0200	0255	
WS 811	2	0	9·12	32·85	25·44	**N 50 V**	90–0	0613	0615	Position re-visited on 12 i 32 when Haul B was taken
		90	6·26	32·88	25·87	**DC**	99	0620	0635	
	5	—	—	—	—	**OTC** **N 7-T** **N 4-T** **NCS-T**	99–99	0701	0801	Haul A
						OTC **N 7-T** **N 4-T** **NCS-T**	97–99	2000	0000	Haul B

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
		1932											
WS 812	From 51° 15·5′ S, 68° 54′ W	10 i	1218	53 gy.S.M	NNW	7–10	N	1	c	1003·6	11·9	9·4	mod. short N swell
	to 51° 17′ S, 68° 50′ W		1420	55 gy.S.M									
	From 51° 17′ S, 68° 50′ W	12 i	1150	44	WSW	11–16	W	1	bc	993·6	14·3	8·9	mod. short W swell
	to 51° 22·5′ S, 68° 30′ W		1715	84									
WS 813	From 51° 34·5′ S, 67° 18·5′ W	13 i	0230	106 d.sk.S	WSW	7–10	W × S	2	b	1000·5	10·6	7·8	mod. short W swell
	to 51° 36′ S, 67° 14′ W		0500	102									
WS 814	From 51° 44·5′ S, 66° 38′ W	13 i	1230	112 c.d. sk.S	SW × W	11–16	SW	3	bc	999·5	11·1	8·8	mod. av. WSW swell
	to 51° 46′ S, 66° 42′ W		1450	119									
WS 815	From 51° 51′ S, 65° 46′ W	13 i	1915	132 c.d. sk.S	W × N	17–21	W	4	o	997·9	11·1	9·4	mod. short to mod. av. W swell
	to 51° 52·5′ S, 65° 42′ W		2145	163									
WS 816	From 52° 09·5′ S, 64° 58′ W	14 i	1040	150 Sn	W	7–10	W × S	3	c	995·6	10·2	7·5	mod. av. W swell
	to 52° 10′ S, 64° 54′ W		1300	150									
WS 817	From 52° 21′ S, 64° 17′ W	14 i	1651	192 d.S	W × N	7–16	W	3	bc	992·3	10·8	8·9	mod. short W swell
	to 52° 25′ S, 64° 21′ W		1905	203									
	to 52° 30·5′ S, 63° 57′ W		2345	238	N	17–21	N	4	cp	977·4	10·6	8·9	mod. av. N swell
WS 818	From 52° 30·5′ S, 63° 27′ W	17 i	0400	272 d.sk.S	WSW	4–10	WSW	2	cd	1005·2	8·6	7·2	mod. short W × S swell
	to 52° 32′ S, 63° 23′ W		0640	278									
	to 52° 37′ S, 63° 02′ W		1140	285	NW	4–6	NW	2	od	1003·8	8·9	7·8	low long NW swell
WS 819	From 52° 41·3′ S, 62° 41′ W	17 i	1438	313 d.sk.S	NW	4–6	NW	1	od	1002·7	8·9	8·6	low long NW swell
	to 52° 42·5′ S, 62° 38′ W		1745	329									
	to 52° 47·5′ S, 62° 17′ W		2235	342	NW	7–10	WSW	3–4	or	998·7	8·9	8·3	mod. short to mod. av. WSW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S ‰	σt	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 812	3	0	9·35	32·55	25·16	**N 50 V**	45–0	1226	1227	Position re-visited on 12 i 32 when Haul B was taken
		45	8·81	32·57	25·27	**DC**	53	1235	1250	
						OTC, N 7-T, N 4-T	53–55	1320	1420	Haul A
	5	—	—	—	—	**N 100 B**	18–0	1221	1241	KT
						OTC, N 7-T, N 4-T, NCS-T	44–84	1315	1715	Haul B. Net possibly not on bottom throughout duration of haul
WS 813	5	0	9·22	33·11	25·62	**N 50 V**	100–0	0255	0257	
		100	6·74	33·12	25·99	**DC**	106	0305	0330	
						OTC, N 7-T, N 4-T, NCS-T	106–102	0400	0500	
WS 814	6	0	8·99	33·22	25·76	**N 50 V**	100–0	1254	1256	
		105	7·25	33·32	26·09	**DC**	112	1305	1315	
						OTC, N 7-T, N 4-T, NCS-T	112–119	1350	1450	
WS 815	6	0	9·14	33·48	25·93	**N 50 V**	100–0	1954	1956	
		130	6·68	33·65	26·42	**OTC, N 7-T, N 4-T, NCS-T**	132–163	2045	2145	
WS 816	6	0	8·59	33·65	26·15	**N 50 V**	100–0	1105	1107	
		150	6·81	33·74	26·47	**DC**	150	1115	1135	Hole in canvas bag
						OTC, N 7-T, N 4-T	150–150	1200	1300	
WS 817	7	0	8·72	33·65	26·13	**N 50 V**	100–0	1711	1713	
		180	6·38	33·86	26·62	**DC**	192	1719	1730	
	7	—	—	—	—	**OTC, N 7-T, N 4-T, NCS-T**	192–203	1805	1905	Haul A
						OTC, N 7-T, N 4-T	203–238	1945	2345	Haul B
WS 818	9	0	7·46	33·70	26·35	**N 50 V**	100–0	0435	0437	
		270	4·91	34·14	27·03	**DC**	272	0445	0513	
	9	—	—	—	—	**OTC, N 7-T, N 4-T, NCS-T**	272–278	0540	0640	Haul A
						OTC, N 7-T, N 4-T, NCS-T	278–285	0740	1140	Haul B. Catch discarded
WS 819	10	0	7·51	33·88	26·49	**N 50 V**	100–0	1506	1508	
		310	4·61	34·14	27·07	**DC**	313	1540	1615	
	10	—	—	—	—	**OTC, N 7-T, N 4-T, NCS-T**	313–329	1645	1745	Haul A

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 819 *cont.*	From 52° 41·3′ S, 62° 41′ W to 52° 42·5′ S, 62° 38′ W to 52° 47·5′ S, 62° 17′ W	1932 17 i											
WS 820	From 52° 52·5′ S, 61° 53·5′ W to 52° 54′ S, 61° 49·5′ W	18 i	0100 0450	351 f.d.S.M 368	NW	7–10	NW	2	od	995·6	8·3	8·1	mod. short N swell
WS 821	From 52° 55′ S, 60° 57′ W to 52° 56·5′ S, 60° 53′ W	18 i	0900 1140	461 f.gn.gy. S.M 468	WNW	7–10	NW	2	bc	993·0	10·0	9·2	low long NW swell
WS 822	53° 11′ S, 60° 12′ W	18 i	1753	662 gn.S.M	WNW	7–16	WNW	3–4	bc	993·1	10·6	8·9	mod. short NW swell
WS 823	From 52° 12·5′ S, 60° 02′ W to 52° 16·5′ S, 60° 00′ W	19 i	0511 0730	80 gn.gy. f.S 95	S	7–10	S	2	or	996·0	6·7	5·6	low long SE swell
WS 824	From 52° 31′ S, 58° 29′ W to 52° 27·5′ S, 58° 25·5′ W	19 i	1900 2105	146 gn.sk. S.Sh 137	W	17–21	WSW	4–5	bc	1004·5	9·4	7·8	mod. av. WSW swell
WS 825	From 50° 50′ S, 57° 13′ W to 50° 50′ S, 57° 17·5′ W	28–29 i	2145 0135	135 gn.S.M. Sh 144	NW	11–21	NW	4	c	978·5	10·0	8·3	mod. av. NW swell
WS 826	50° 50′ S, 58° 31·5′ W	29 i	0915	150	WNW	11–16	WNW	3	c	980·4	8·9	7·7	mod. av. WNW swell
WS 827	50° 51′ S, 60° 06′ W	30 i	1025	137 St	SE × E	1–6	ESE	1	c	997·8	7·2	4·0	low long ESE swell
WS 828	50° 51′ S, 61° 42′ W	30 i	1855	155	WNW	4–6	WNW	2	cp	998·3	8·1	5·6	low long to mod. short NW swell
WS 829	50° 51′ S, 63° 13·5′ W	31 i	0244	155	W × S	4–21	W × S	2	bcq	996·2	7·2	5·0	mod. short W swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S ‰	σt	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 819 *cont.*	10					OTC N 7-T N 4-T NCS-T	329–342	1835	2235	Haul B
WS 820	10	0 350	7·64 4·27	33·96 34·13	26·53 27·08	N 50 V DC	100–0 351	0132 0245	0135	
						OTC N 7-T N 4-T	351–368	0345	0450	
WS 821	10	0 450	7·92 4·11	33·90 34·17	26·44 27·14	N 50 V DC	100–0 461	0925 1015	0927 1045	
						OTC N 7-T N 4-T NCS-T	461–468	1120	1140	Trawl came up foul
						LB	0	1245		
WS 822	11	0 660	7·40 4·01	34·00 34·18	26·60 27·16	N 50 V	100–0	1830	1832	
WS 823	11	0 75	9·10 8·41	33·68 33·74	26·09 26·24	N 50 V DC	75–0 80	0543 0550	0545 0605	
						OTC N 7-T N 4-T NCS-T	80–95	0630	0730	Net torn
WS 824	11	0 140	8·30 5·45	33·81 33·87	26·32 26·75	N 50 V DC	100–0 146	1927 1935	1929 1945	
						OTC N 7-T N 4-T NCS-T	146–137	2000	2105	
WS 825	21	0 130	8·12 5·61	33·78 33·91	26·32 26·76	N 50 V DC	100–0 135	2202 2220	2204 2235	
						OTC N 7-T N 4-T NCS-T	135–144	0035	0135	
						N 70 B N 100 B	68–0	0254	0314	KT
						NR	144(–0)	0254	0324	
WS 826	21	0 145	9·01 5·54	33·78 33·92	26·19 26·78	N 50 V	100–0	0941	0943	
						N 70 B N 100 B	98–0	1021	1041	KT
						NR	150(–0)	1021	1051	
WS 827	22	0 130	9·34 5·67	33·87 33·74	26·20 26·62	N 50 V	100–0	1050	1052	
						N 70 B N 100 B	87–0	1131	1151	KT
						NR	137(–0)	1131	1201	
WS 828	23	0 150	8·83 5·21	33·78 33·97	26·22 26·86	N 50 V	100–0	1905	1907	
						N 70 B N 100 B	128–0	1942	2002	KT
						NR	155(–0)	1942	2012	
WS 829	23	0 150	9·22 5·82	33·68 33·77	26·07 26·62	N 50 V	100–0	0256	0258	
						N 70 B N 100 B	120–0	0339	0359	Depth estimated
						NR	155(–0)	0339	0424	

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 830	50° 50′ S, 64° 43′ W	1932 31 i	1135	143	W×S	11–16	WSW	3	c	1001·5	9·7	7·8	mod. av. WSW swell
WS 831	50° 50·5′ S, 66° 10·5′ W	31 i	1944	119	SW	7–10	SW	2	bc	1006·1	8·3	5·6	mod. short SW×S swell
WS 832	50° 49′ S, 67° 55′ W	1 ii	0336	95	WSW	7–10	SW	2	c	1005·6	8·9	5·6	low long SW swell
WS 833	From 52° 28′ S, 68° 00′ W	1 ii	1610	38 b.gy. M.f.S	SW×W	4–6	SW	2	bc	1000·8	11·4	7·8	low long SW swell
	to 52° 32′ S, 68° 00′ W		1900	31									
WS 834	From 52° 57′ S, 68° 07′ W	2 ii	0520	27 d.b.gy. Sn.St. M.S	W×N	11–16	W	3	c	996·0	7·8	5·0	low long W×S swell
	to 52° 58·5′ S, 68° 09·5′ W		0725	38									
WS 835	53° 05·5′ S, 68° 06·5′ W	2 ii	1000	15 St	W	17–21	W	3	c	993·9	—	—	mod. av. W swell
			1150	16									
WS 836	53° 05·5′ S, 67° 38′ W	3 ii	0910	64	NW×W	7–10	NW×W	2–3	bc	992·2	10·6	8·9	mod. short NW×W swell
WS 837	From 52° 48·5′ S, 66° 30′ W	3 ii	1512	102 c.d.gn. S.P	NW	7–10	NNW	2	bc	990·8	13·3	10·0	mod. short NNW swell
	to 52° 50′ S, 66° 26′ W		1725	102									
WS 838	From 53° 11′ S, 65° 02′ W	5 ii	1042	149 c.d.sk. S.P	W×S	11–16	W	4	c	999·1	10·0	7·8	mod. av. W swell
	to 53° 12·5′ S, 64° 58′ W		1307	159									
WS 839	From 53° 29·5′ S, 63° 31′ W	5 ii	1940	503 f.S.M	N×W	4–6	N×W	2–3	or	988·2	8·3	7·2	mod. short NW swell
	to 53° 31′ S, 63° 27′ W		2307	534									
WS 840	From 53° 51·5′ S, 61° 51·5′ W	6 ii	0840	368 gn.gy.S	SW	4–10	WSW	2–3	b	990·0	8·3	7·5	mod. short W×S swell
	to 53° 52·5′ S, 61° 47′ W		1115	463									
WS 841	From 54° 11′ S, 60° 23′ W	6 ii	1810	110 Sn.Sh	NW	4–6	NW	2	bc	993·4	8·9	7·2	mod. short WNW swell
	to 54° 12·5′ S, 60° 20′ W		2040	121									

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 830	24	0	9·33	33·49	25·90	N 50 V	100–0	1147	1149	
		140	6·38	33·42	26·28	N 70 B	84–0	1222	1242	KT
						N 100 B				
						NR	143(–0)	1222	1252	
WS 831	24	0	9·71	33·24	25·65	N 50 V	100–0	1955	1957	
		110	6·85	33·25	26·07	N 70 B	83–0	2025	2045	KT
						N 100 B				
						NR	119(–0)	2025	2100	
WS 832	24	0	9·93	—	—	N 50 V	90–0	0415	0417	
		90	7·21	32·89	25·76	N 70 B	75–0	0505	0525	Depth estimated
						N 100 B				
						NR	95(–0)	0505	0539	
WS 833	25	0	9·54	32·89	25·41	N 50 V	35–0	1625	1626	
		35	9·21	32·89	25·46	DC	38	1700		
						OTC	38–31	1800	1900	
						N 7-T				
						N 4-T				
						NCS-T				
WS 834	25	0	9·61	32·79	25·32	N 50 V	25–0	0530	0531	
						DC	27	0540	0550	
						OTC	27–38	0625	0725	
						N 7-T				
						N 4-T				
						NCS-T				
WS 835	25	—	—	—	—	DC	15	1005	1015	Depth by hand lead
						BTS	15–16	1120	1150	
WS 836	26	0	9·71	32·88	25·37	N 50 V	50–0	0930	0931	
		60	9·68	32·84	25·34	BTS	64	0950	1020	
WS 837	27	0	9·13	33·08	25·61	N 50 V	95–0	1520	1522	
		95	8·41	33·19	25·81	DC	102	1528	1545	
						OTC	102–102	1625	1725	
						N 7-T				
						N 4-T				
						NCS-T				
WS 838	29	0	7·86	33·64	26·25	N 50 V	100–0	1048	1050	
		140	7·60	33·75	26·37	DC	149	1107	1120	
						OTC	149–159	1207	1307	
						N 7-T				
						N 4-T				
						NCS-T				
WS 839	29	0	6·55	34·07	26·77	N 50 V	100–0	1950	1952	
		400	4·28	34·20	27·14	DC	503	2045	2115	
						OTC	503–534	2207	2307	
						N 7-T				
						N 4-T				
						NCS-T				
WS 840	29	0	6·87	34·09	26·74	N 50 V	100–0	0905	0907	
		360	4·35	34·18	27·12	DC	368	0915	0945	
						OTC	368–463	1015	1115	
						N 7-T				
						N 4-T				
						NCS-T				
WS 841	0	0	7·10	34·07	26·70	N 50 V	100–0	1817	1819	
		100	6·81	34·07	26·74	DC	110	1840	1855	

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 841 *cont.*	From 54° 11′ S, 60° 23′ W to 54° 12·5′ S, 60° 20′ W	1932 6 ii											
WS 842	53° 34′ S, 61° 36′ W	7 ii	0510	688 gn.S.M	NW	11–16	NW	3–4	bc	994·0	8·9	7·8	mod. short to mod. av. NW × W swell
WS 843	52° 53′ S, 62° 54′ W	7 ii	1418	338	NW	11–16	NW	2	om	988·6	11·1	10·0	mod. short NW swell
WS 844	52° 14′ S, 64° 10′ W	7–8 ii	2220	218	W	11–16	W × S	2	bc	992·1	10·6	8·9	mod. short W × S swell
WS 845	51° 30′ S, 65° 25′ W	8 ii	1135	141	W × N	11–16	WNW	3	c	994·1	11·1	8·9	mod. short W × N swell
WS 846	50° 56′ S, 66° 40′ W	8 ii	2101	110	WNW	7–10	WNW	2	bc	986·5	11·6	10·0	low long WNW swell
WS 847	From 50° 15′ S, 67° 59′ W to 50° 16·5′ S, 67° 55′ W to 50° 21′ S, 67° 33′ W	9 ii	0646 0915 1200 1420	51 57 — 84	SW × W SW	17–27 17–21	SW WSW	4 4	bc bc	992·5 996·0	11·1 10·6	10·0 7·8	mod. av. WSW swell mod. av. SW × W swell
WS 848	From 50° 37′ S, 66° 26′ W to 50° 38′ S, 66° 22′ W	10 ii	1115 1325	115 d.gn.S 117	W × N	7–10	W	2	bc	1003·8	11·1	8·2	mod. short W × N swell
WS 849	From 50° 56·5′ S, 65° 00′ W to 50° 57′ S, 64° 56′ W	10 ii	1929 2145	137 d.S 137	W × N	4–10	W × N	2	bc	1002·8	11·7	8·9	mod. short W swell
WS 850	From 51° 18′ S, 63° 31·5′ W to 51° 19·5′ S, 63° 29′ W	11 ii	0602 0838	157 d.gn. S.St 166	W × N	7–10	W × N	2	bc	1005·3	10·6	8·9	mod. short W swell
WS 851	From 51° 39′ S, 62° 02·5′ W to 51° 41′ S, 62° 00′ W	11 ii	1504 1715	221 St 198	WSW	7–10	WSW	3	b	1009·9	9·7	8·9	low long WSW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 841 *cont.*	0					**OTC N 7-T N 4-T NCS-T**	110–121	1930	2040	Foot rope parted during tow
						N 70 B N 100 B	91–0	**2125**	**2145**	Depth estimated
WS 842	1	0	7·05	34·08	26·71	**N 50 V**	100–0	**0519**	**0521**	
		600	4·07	34·18	27·15	**N 70 B N 100 B**	100–0	0612	0632	Depth estimated
WS 843	1	0	8·31	33·70	26·28	**N 50 V**	100–0	1425	1427	
		300	5·20	34·14	27·00	**N 70 B N 100 B**	102–0	1503	1523	KT
						NR	338(–0)	1503	1533	
WS 844	1	0	8·49	33·69	26·19	**N 50 V**	100–0	**2228**	**2230**	
		200	6·50	33·96	26·69	**N 70 B N 100 B**	91–0	**2319**	**0030**	KT
						NR	218(–0)	**2319**	**0125**	Haul irregular
WS 845	2	0	9·11	33·61	26·04	**N 50 V**	100–0	1158	1200	
		140	7·21	33·75	26·43	**N 70 B N 100 B**	100–0	1240	1302	KT
						NR	141(–0)	1240	1310	
WS 846	2	0	10·04	33·18	25·55	**N 50 V**	100–0	**2107**	**2109**	
		100	6·84	33·18	26·03	**N 70 B N 100 B**	98–0	**2136**	**2156**	KT
						NR	110(–0)	**2136**	**2215**	Net did not fish properly
WS 847	3	0	10·86	32·78	25·10	**N 50 V**	45–0	0728	0729	
		45	10·89	32·81	25·11	**DC**	51	0740	—	Temperature repeated
	3	—	—	—	—	**OTC N 7-T N 4-T NCS-T**	51–57	0815	0915	Haul A
						OTC N 7-T N 4-T NCS-T	57–84	1020	1420	Haul B. Net torn
WS 848	4	0	10·41	33·23	25·53	**N 50 V**	110–0	1130	1132	
		110	7·12	33·27	26·06	**DC**	115	1147	1200	
						OTC N 7-T N 4-T NCS-T	115–117	1225	1325	Trawl torn
WS 849	4	0	9·25	33·40	25·85	**N 50 V**	100–0	1935	1937	
		130	6·76	33·40	26·22	**DC**	137	2010	2025	
						OTC N 7-T N 4-T NCS-T	137–137	2045	**2145**	
WS 850	5	0	8·89	33·65	26·10	**N 50 V**	100–0	0623	0625	
		150	6·40	33·78	26·57	**DC**	157	0650	0710	
						OTC N 7-T N 4-T NCS-T	157–166	0730	0838	
WS 851	5	0	8·81	33·75	26·19	**N 50 V**	115–0	1509	1511	
		200	5·38	34·05	26·90	**DC**	221	1530	1550	

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 851 *cont.*	From 51° 39′ S, 62° 02·5′ W to 51° 41′ S, 62° 00′ W	1932 11 ii											
WS 852	44° 12·5′ S, 64° 13′ W	21 iii	0600 0812	84 88	N × W	4–6	N	2	bc	1004·7	17·2	14·4	low long to mod. short N × W swell
WS 853	From 44° 38′ S, 64° 15′ W to 44° 41·5′ S, 64° 12′ W	21 iii	1122 1320	90 90	N × W	1–3	N	1	bc	1006·5	17·9	14·4	low long N swell
WS 854	45° 16′ S, 64° 25′ W	22 iii	0524 0816	97 97	N	1–6	N	1–2	bc	1004·8	16·3	15·0	low long to mod. short N × W swell
WS 855	From 45° 56′ S, 64° 10′ W to 45° 59′ S, 64° 12′ W	22 iii	1250 1440	115 110	E × N	1–3	N	1–2	c	1003·4	16·1	15·0	low long to mod. short ENE swell
WS 856	46° 35′ S, 64° 11′ W	23 iii	0600 0806	104 104	NW	1–6	NW	1	bc	1006·2	15·0	12·2	low long to mod. short WNW swell
WS 857	From 47° 11′ S, 64° 15′ W to 47° 12′ S, 64° 09′ W	23 iii	1236 1435	123 124	WNW	4–10	NW	2	b	1006·1	15·5	12·8	low long to mod. short NW swell
WS 858	From 45° 42′ S, 60° 30′ W to 45° 40·5′ S, 60° 33′ W	24 iii	1222 1445	132 123	SSE	4–10	S	2	om	1011·8	12·8	11·7	low long S swell
WS 859	From 45° 14′ S, 61° 56′ W to 45° 12′ S, 62° 00′ W to 45° 10′ S, 62° 03′ W	25 iii	0605 0850 1032	106 110 106	W	4–10	WSW	2	b	1020·1	13·9	11·7	low long to mod. short WSW swell
WS 860	From 44° 53′ S, 63° 30′ W to 44° 55′ S, 63° 32′ W	25 iii	1841 2030	101 104	N × W	11–16	NW	3–4	b	1018·4	15·3	13·9	mod. short NW × N swell
WS 861	47° 40′ S, 64° 12′ W	27 iii	0600 0800	117 124	N	1–3	N	1–2	b	1023·3	13·6	11·7	low long NW swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 851 *cont.*	5					OTC N 7-T N 4-T NCS-T	221–198	1615	1715	
WS 852	14	0 80	15·10 10·51	33·51 33·38	24·83 25·62	N 50 V N 70 B NR BTS	80–0 71–0 84(–0) 86–88	**0620** 0657 0657 0742	**0622** 0717 0727 0812	+4 hours KT
WS 853	14	0 85	14·71 8·14	33·45 33·38	24·86 26·00	N 50 V OTC N 7-T N 4-T NCS-T	80–0 90–90	1138 1220	1140 1320	
WS 854	15	0 90	14·73 7·16	33·32 33·33	24·76 26·10	N 50 V N 70 B N 100 B NR BTS	90–0 74–0 97(–0) 97–97	0634 0658 0658 0746	0636 0718 0728 0816	KT
WS 855	15	0 110	14·71 6·78	33·34 33·41	24·78 26·22	N 50 V OTC N 7-T N 4-T NCS-T	100–0 115–110	1306 1340	1308 1440	
WS 856	16	0 100	13·61 7·32	33·54 33·33	25·16 26·08	N 50 V N 70 B N 100 B NR BTS	100–0 85–0 104(–0) 104–104	**0620** 0643 0643 0736	**0622** 0703 0713 0713 0806	KT
WS 857	16	0 120	13·49 8·02	33·62 33·58	25·25 26·18	N 50 V OTC N 7-T N 4-T NCS-T	100–0 123–124	1304 1335	1306 1435	
WS 858	17	0 130	12·71 5·96	33·60 33·63	25·39 26·51	N 50 V OTC N 7-T N 4-T NCS-T	100–0 132–123	1303 1335	1305 1445	
WS 859	18	0 100	14·08 6·71	33·64 33·68	26·14 26·44	N 50 V OTC N 7-T N 4-T NCS-T OTC N 7-T N 4-T NCS-T	100–0 106–110 110–106	0717 0750 0932	0719 0850 1032	Haul A Haul B
WS 860	18	0 100	15·06 7·21	33·36 33·44	24·72 26·18	N 50 V OTC N 7-T N 4-T NCS-T	100–0 101–104	**1902** **1930**	**1904** **2030**	
WS 861	20	0 90	12·38 8·91	33·45 33·58	25·34 26·05	N 50 V N 70 B N 100 B NR BTS	90–0 68–0 117(–0) 117–124	**0619** 0639 0639 0730	**0621** 0659 0709 0709 0800	Depth estimated Net probably off bottom during part [of tow

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 862	From 48° 23′ S, 64° 15′ W to 48° 26′ S, 64° 13′ W	1932 27 iii	1255 1435	112 115	Lt airs	0	—	0	b	1024·7	15·3	13·1	low av. N×W swell
WS 863	49° 05′ S, 64° 09′ W	28 iii	0600 0817	121 117	N×W	7–16	N×W	2–3	b	1019·3	11·9	10·0	mod. short N swell
WS 864	From 49° 32′ S, 64° 15′ W to 49° 35′ S, 64° 17′ W	28 iii	1109 1255	128 126	NNW	7–10	N×W	2	b	1018·4	12·2	11·1	mod. short N×W swell
WS 865	50° 03′ S, 64° 14′ W	29 iii	0514 0748	126 128	NNW	11–21	NNW	3	c	1010·5	10·6	8·9	mod. av. NW swell
WS 866	From 50° 36′ S, 64° 15′ W to 50° 39·5′ S, 64° 15′ W	29 iii	1210 1358	137 144	N×W	7–10	NNW	3	o	1011·0	10·1	9·9	mod. av. NNW swell
WS 867	51° 10′ S, 64° 15·5′ W	30 iii	0600 0830	150 148	NNE	17–21	NNE	4	om	1002·4	9·4	8·9	mod. short to mod. av. N swell
WS 868	From 51° 45′ S, 64° 16′ W to 51° 46·5′ S, 64° 17′ W	30 iii	1245 1440	166 163	W×S	7–10	conf.	3	or	1001·7	8·8	8·6	mod. av. conf. swell
WS 869	52° 15·5′ S, 64° 13·8′ W	31 iii	0600 0825	187 201	W×N	7–10	W	3	bc	1001·4	9·2	6·1	mod. short W×N swell
WS 870	From 52° 49′ S, 64° 15′ W to 52° 50′ S, 64° 10′ W	31 iii	1300 1500	269 276	WSW	4–6	W	2	bc	1000·2	9·9	7·8	mod. short W swell
WS 871	53° 16′ S, 64° 12′ W	1 iv	0600 0955	336 342	S	1–6	S	1	b	1007·1	7·5	5·6	low long SW swell
WS 872	From 53° 49′ S, 64° 15′ W to 53° 47′ S, 64° 22′ W	1 iv	1510 1705	139 134	S	4–6	S	1	bc	1007·8	8·9	6·7	low long S swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS Depth (metres)	Temp. °C.	S °/₀₀	σt	BIOLOGICAL OBSERVATIONS Gear	Depth (metres)	TIME From	To	Remarks
WS 862	20	0	12·21	33·41	25·34	N 50 V	100–0	1309	1311	
		110	8·42	33·45	26·02	OTC				
						N 7-T	112–115	1335	1435	
						N 4-T				
						NCS-T				
WS 863	21	0	10·20	33·41	25·70	N 50 V	100–0	0624	0626	
		120	7·38	33·33	26·07	N 70 B	71–0	0647	0707	KT
						N 100 B				
						NR	121(–0)	0647	0717	
						BTS	121–117	0747	0817	
WS 864	21	0	9·93	33·41	25·75	N 50 V	100–0	1124	1126	
		120	7·51	33·45	26·15	OTC				
						N 7-T	128–126	1155	1255	
						N 4-T				
						NCS-T				
WS 865	22	0	9·36	—	—	N 50 V	100–0	0634	0636	
		120	7·70	33·37	26·06	N 70 B	79–0	0700	0720	KT
						N 100 B				
						NR	126(–0)	0700	0733	
						BTS	126–128	0742	0812	
WS 866	22	0	9·01	33·51	25·97	N 50 V	100–0	1226	1228	
		130	7·41	33·52	26·22	OTC				
						N 7-T	137–144	1258	1358	
						N 4-T				
						NCS-T				
WS 867	23	0	8·62	33·83	26·29	N 50 V	100–0	0628	0630	
		150	7·81	34·30	26·77	N 70 B	95–0	0655	0715	KT
						N 100 B				
						NR	150(–0)	0655	0725	
						BTS	150–148	0748	0818	
WS 868	23	0	8·24	33·64	26·19	N 50 V	100–0	1307	1309	
		160	7·93	33·70	26·28	OTC				
						N 7-T	166–163	1340	1440	
						N 4-T				
						NCS-T				
WS 869	24	0	8·02	33·62	26·21	N 50 V	100–0	0626	0628	
		180	7·18	33·81	26·48	N 70 B	120–0	0650	0710	KT
						N 100 B				
						NR	187(–0)	0650	0730	
						BTS	187–201	0755	0825	
WS 870	24	0	7·99	33·55	26·16	N 50 V	100–0	1323	1325	
		250	6·19	33·98	26·75	OTC	269–276	1400	1500	Nets probably not fishing properly
						NCS-T				
WS 871	25	0	7·49	33·71	26·36	N 50 V	100–0	0627	0629	
		300	5·91	34·17	26·93	N 70 B	137–0	0705	0725	KT
						N 100 B				
						NR	336(–0)	0705	0750	
						BTS	336–342	0925	0955	
WS 872	25	0	7·49	33·62	26·29	N 50 V	100–0	1530	1532	
		135	6·61	33·87	26·61	OTC				
						N 7-T	139–134	1605	1705	
						N 4-T				
						NCS-T				

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 873	52° 35′ S, 67° 19′ W	1932 2 iv	1900	93	W	1–3	—	0	bc	1017·2	8·9	6·7	low av. to low long SW swell
WS 874	From 52° 35′ S, 65° 17′ W to 52° 36′ S, 65° 11′ W	3 iv	0700 1010	135 132	WSW	4–6	SW	1	c	1018·0	9·2	8·3	low long W swell
WS 875	From 52° 35′ S, 63° 50′ W to 52° 37′ S, 63° 45·5′ W	3 iv	1523 1655	252 234	SE	4–10	SE	2	c	1018·2	8·3	6·7	low long to mod. short ESE swell
WS 876	52° 35′ S, 63° 17′ W	3 iv	1948	263	SSE	4–6	SSE	2	od	1017·3	7·2	5·6	low long to mod. short S swell
WS 877	52° 35·5′ S, 61° 04′ W	4 iv	0720	349	S×W	11–16	S	3–4	c	1013·7	6·7	3·9	mod. short to mod. av. S swell
WS 878	52° 36′ S, 58° 54′ W	4 iv	2045	121	SE	17–21	SE	4	c	1010·3	6·1	4·4	mod. av. to mod. long SE swell
WS 879	51° 39′ S, 57° 39′ W	5 iv	0705	53	SSW	11–21	S	4	c	1010·8	6·7	5·0	mod. av. to mod. long S swell
WS 880	50° 31′ S, 57° 33′ W	16 iv	2000	302	NE	17–21	N	4	cr	975·6	3·9	3·3	mod. short N swell
WS 881	47° 28′ S, 57° 18′ W	17 iv	2000	—	W	7–10	W	2	c	1002·2	7·8	5·6	mod. short W swell
WS 882	41° 05·5′ S, 56° 21′ W	19 iv	2000	1194	NNW	7–10	N	2	b	1012·4	10·6	8·9	mod. short N swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 873	27	0	9·17	33·12	25·64	**N 50 V**	90–0	**1917**	**1919**	
		90	8·98	33·48	25·95	**N 70 B**, **N 100 B**	80–0	**1942**	**2002**	Depth estimated
						NR	93(–0)	**1942**	**2012**	
WS 874	27	0	8·51	—	—	**N 50 V**	100–0	0720	0722	
		130	8·29	33·51	26·09	**N 70 B**, **N 100 B**	73–0	0746	0806	KT
						NR	135(–0)	0746	0816	
						OTC, **N 7-T**, **N 4-T**, **NCS-T**	135–132	0910	1010	Catches discarded
WS 875	27	0	7·81	33·57	26·20	**OTC**, **N 7-T**, **N 4-T**, **NCS-T**	252–234	1555	1655	Catches discarded
		230	6·38	33·99	26·74					
WS 876	28	0	7·59	33·72	26·35	**N 50 V**	100–0	**2019**	**2021**	
		250	5·36	34·10	26·94	**N 70 B**, **N 100 B**	135–0	**2043**	**2105**	KT
						NR	263(–0)	**2043**	**2116**	
WS 877	28	0	5·58	33·83	26·71	**N 50 V**	100–0	0751	0753	
		340	4·86	34·15	27·05	**N 70 B**, **N 100 B**	88–0	0820	0840	KT
						NR	349(–0)	0820	0910	
WS 878	29	0	7·47	33·89	26·50	**N 50 V**	100–0	**2108**	**2110**	
		120	6·78	33·93	26·62	**N 70 B**, **N 100 B**	84–0	**2134**	**2154**	KT
						NR	121(–0)	**2134**	**2204**	
WS 879	29	0	8·45	33·76	26·26	**N 50 V**	50–0	0727	0729	
		50	8·44	33·74	26·24	**N 70 B**	53–0	0745	0805	Depth estimated
WS 880	11	—	—	—	—	**N 50 V**	100–0	**2020**	**2022**	
						TYF	*ca.* 300–0	**2108**	**2133**	Depth estimated. Net badly torn
WS 881	12	0	7·10	34·09	26·71	**N 50 V**	100–0	**2010**	**2012**	
						TYF	*ca.* 700–0	**2039**	**2129**	Depth estimated
WS 882	14	0	8·75	34·07	26·45	**N 50 V**	100–0	**2009**	**2011**	
						TYF	*ca.* 700–0	**2049**	**2139**	Depth estimated

R.R.S. 'WILLIAM SCORESBY'
WHALE-MARKING CRUISE
STATIONS WS 883–895

31. xii. 1934—20. ii. 1935

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 883	61° 06′ S, 90° 18′ E	1934 31 xii	0010	400	SE × E	4–6	SE × E	2	os	977·1	0·6	0·6	conf. swell
WS 884	60° 16′ S, 90° 18′ E	31 xii	0900	400	NE × N	4–6	NE × N	2	o	979·3	0·6	0·6	conf. swell
WS 885	59° 25′ S, 90° 13′ E	31 xii	1600	400	NNE	4–6	NNE	2	o	979·3	1·7	1·1	mod. long swell
WS 886	From 63° 34′ S, 83° 41′ E to 63° 30′ S, 83° 30′ E	1935 4 i	0935 1400	400	E × S	34–40	E × S	5	o	965·4	0·0	—	low long swell
WS 887	66° 10′ S, 58° 47′ E	12 i	2215	400	E × N	28–33	E × N	4	o	987·5	0·0	—	mod. av. swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S.°/°°	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 883	24	0	−0·19	33·79	27·17	—	—	—	—	+6 hours 25 minutes
		10	−0·19	33·79	27·17					
		20	−0·24	33·81	27·18					
		30	−1·29	34·03	27·40					
		40	−1·44	34·06	27·43					
		50	−1·54	34·14	27·50					
		60	−1·64	34·23	27·57					
		80	−1·49	34·32	27·64					
		100	−1·39	34·33	27·64					
		150	−0·59	34·34	27·63					
		200	0·21	34·52	27·73					
		300	1·07	34·64	27·78					
		400	1·42	34·70	27·80					
WS 884	24	0	−0·04	33·79	27·16					
		10	−0·04	33·79	27·16					
		20	−0·07	33·79	27·16					
		30	−0·09	33·80	27·16					
		40	−0·14	33·81	27·18					
		50	−0·01	33·94	27·27					
		60	−0·04	33·97	27·30					
		80	−0·59	34·05	27·39					
		100	−0·84	34·14	27·48					
		150	−0·49	34·23	27·53					
		200	−1·59	34·29	27·61					
		300	−0·24	34·47	27·71					
		400	0·76	34·59	27·76					
		150	−0·34	34·27	27·56	—	—	—	—	Repeated after 400 m. haul
WS 885	24	0	0·36	33·76	27·11					
		10	0·16	33·79	27·15					
		20	0·06	33·83	27·19					
		30	0·06	33·83	27·19					
		40	−0·01	33·84	27·19					
		50	−0·14	33·85	27·21					
		60	−0·87	33·87	27·26					
		80	−1·11	33·97	27·35					
		100	−1·14	34·05	27·41					
		150	−0·64	34·22	27·52					
		200	0·36	34·35	27·59					
		300	1·77	34·59	27·69					
		400	1·90	34·68	27·75					
WS 886	29	0	−1·02	33·72	27·14	N 70 B N 100 B	100–0	1334	1354	Strong head wind in pack-ice. +6 hours 5 minutes. Depth estimated
		10	−1·04	33·72	27·14					
		20	−1·07	33·72	27·14					
		30	−1·14	34·05	27·41					
		40	−0·74	34·33	27·61					
		50	−0·34	34·38	27·65					
		60	0·51	34·48	27·68					
		80	1·27	34·58	27·71					
		100	1·57	34·62	27·73					
		150	1·67	34·64	27·73					
		200	1·77	34·67	27·75					
		300	1·79	34·70	27·77					
		400	1·77	34·71	27·79					
WS 887	8	0	−1·10	33·54	27·00	—	—	—	—	+4 hours 40 minutes
		10	−1·09	33·54	26·99					
		20	−1·09	33·54	26·99					
		30	−1·52	33·90	27·30					
		40	−1·74	34·08	27·46					
		50	−1·74	34·17	27·53					
		60	−1·74	34·18	27·54					
		80	−1·71	34·23	27·57					
		100	−1·71	34·29	27·62					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 887 *cont.*	66° 10′ S, 58° 47′ E	1935 12 i											
WS 888	From 64° 25′ S, 56° 13′ E to 64° 24·5′ S, 56° 09′ E	13–14 i	2200 0035	$\frac{\cdot}{400}$	E × S	7–10	E × S	2	os	992·9	0·0	—	mod. short swell
WS 889	64° 12′ S, 54° 06′ E	14 i	2200	$\frac{\cdot}{400}$	SE	22–27	SE	5	c	994·0	0·0	—	mod. short swell
WS 890	64° 29′ S, 49° 43′ E	20 i	2140	$\frac{\cdot}{400}$	N	4–6	N	2	os	992·9	0·0	—	low short swell
WS 891	63° 30′ S, 47° 49′ E	21 i	2150	$\frac{\cdot}{400}$	N	4–6	N	2	os	989·9	−0·6	—	low short swell
WS 892	From 64° 49′ S, 09° 02′ E to 64° 49′ S, 09° 06′ E	15–16 ii	2330 0140	$\frac{\cdot}{400}$	NE × E	4–6	NE × E	2	os	987·9	0·0	—	conf. swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 887 *cont.*	8	150	−1·69	34·35	27·68					
		200	−1·69	34·36	27·68					
		300	−1·54	34·43	27·73					
		400	−1·32	34·51	27·79					
WS 888	9	0	−0·14	33·87	27·23	N 70 B N 100 B	100–0	2335	2355	Depth estimated.
		10	−0·14	33·87	27·23					
		20	−0·22	33·91	27·26	N 100 H	2–0	0010	0030	+4 hours 10 minutes
		30	−0·24	33·93	27·27					
		40	−1·68	34·19	27·54					
		50	−1·74	34·20	27·55					
		60	−1·74	34·22	27·56					
		80	−1·54	34·24	27·58					
		100	1·17	34·51	27·66					
		150	1·47	34·59	27·71					
		200	1·52	34·63	27·74					
		300	1·57	34·69	27·77					
		400	1·57	34·69	27·77					
WS 889	10	0	0·16	33·94	27·26	N 100 H	5–0	2325	2345	+3 hours 40 minutes
		10	0·16	33·94	27·26					
		20	0·14	33·94	27·26					
		30	−0·12	33·95	27·29					
		40	−1·58	34·15	27·51					
		50	−1·72	34·19	27·54					
		60	−1·72	34·20	27·55					
		80	−1·39	34·26	27·59					
		100	0·87	34·52	27·69					
		150	1·44	34·62	27·74					
		200	1·52							
		300	1·57	34·70	27·79					
		400	1·57	34·70	27·79					
WS 890	16	0	−0·04	33·49	26·91	N 100 H	5–0	2146	2206	+3 hours
		10	−0·14	33·52	26·95					
		20	−0·22	33·77	27·14					
		30	−1·36	33·99	27·37					
		40	−1·64	34·14	27·50					
		50	−1·74							
		60	−1·74							
		80	−1·70	34·31	27·64					
		100	−1·44	34·40	27·70					
		150	0·33	34·58	27·77					
		200	0·87	34·64	27·79					
		300	1·30	34·69	27·79					
		400	1·07	34·69	27·81					
WS 891	16	0	0·87	33·78	27·10	N 100 H	5–0	2200	2220	+2 hours 50 minutes
		10	0·82	33·86	27·15					
		20	0·64	33·86	27·17					
		30	−0·77	33·93	27·30					
		40	−1·62	33·93	27·32					
		50	−1·64	34·15	27·51					
		60	−1·54	34·23	27·57					
		80	−0·79	34·36	27·65					
		100	0·36	34·54	27·74					
		150	1·37	34·63	27·75					
		200	1·50	34·68	27·78					
		300	1·52	34·69	27·78					
		400	1·46	34·69	27·78					
WS 892	12	0	0·67	33·94	27·23	N 100 B	100–0	0110	0130	Depth estimated. +0 hour 30 minutes
		10	0·71	33·94	27·23					
		20	0·70	33·94	27·23					
		30	0·66	33·94	27·23					
		40	0·08	34·02	27·34					

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 892 *cont.*	From 64° 49′ S, 09° 02′ E to 64° 49′ S, 09° 06′ E	1935 15–16 ii											
WS 893	63° 13′ S, 05° 29′ E	16 ii	2105	$\frac{\cdot}{400}$	SE × S	17–21	SE × S	4	o	989·2	0·0	—	conf. swell
WS 894	61° 29′ S, 04° 13′ E	17 ii	2100	$\frac{\cdot}{400}$	SSW	11–16	SSW	3	os	992·2	0·0	0·0	conf. swell
WS 895	61° 36′ S, 14° 43′ E	20 ii	2010	$\frac{\cdot}{400}$	WSW	22–27	WSW	5	c	1001·7	0·6	—	mod. short swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S °/°°	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 892 *cont.*	12	50	−1·22	34·32	27·63					
		60	−1·44	34·40	27·70					
		80	−0·54	34·51	27·76					
		100	0·29	34·60	27·78					
		150	0·94	34·67	27·80					
		200	1·17	34·68	27·80					
		300	1·25	34·71	27·82					
		400	1·17	34·74	27·85					
WS 893	13	0	1·00	33·94	27·21	N 100 B	100–0	2117	2137	Depth estimated. +0 hour 15 minutes
		10	1·00	33·94	27·21					
		20	0·97	33·94	27·21					
		30	0·97	33·94	27·21					
		40	0·77	33·94	27·23					
		50	0·06	33·98	27·31					
		60	−1·13	34·14	27·49					
		80	−1·69	34·31	27·63					
		100	−1·69	34·31	27·63					
		150	−1·77	34·39	27·71					
		200	0·36	34·61	27·80					
		300	0·55	34·67	27·83					
		400	0·46	34·67	27·83					
WS 894	14	0	0·60	33·71	27·06	N 100 B	100–0	2218	2238	Depth estimated. GMT
		10	0·59	33·75	27·09					
		20	0·62	33·78	27·12					
		30	0·52	33·95	27·25					
		40	−0·04	34·05	27·36					
		50	−1·62	34·27	27·60					
		60	−1·69	34·28	27·61					
		80	−1·72	34·28	27·62					
		100	−1·69	34·29	27·61					
		150	−1·34	34·40	27·70					
		200	0·26	34·62	27·82					
		300	0·38	34·67	27·84					
		400	0·38	34·70	27·87					
WS 895	17	0	1·05	33·86	27·14	N 100 B	100–0	2119	2139	Depth estimated. +0 hour 20 minutes
		10	1·05	33·86	27·14					
		20	1·05	33·86	27·14					
		30	1·02	33·86	27·14					
		40	0·85	33·87	27·17					
		50	−1·20	34·11	27·46					
		60	−1·53	34·20	27·54					
		80	−1·54	34·27	27·60					
		100	−0·74	34·39	27·68					
		150	0·77	34·62	27·79					
		200	0·97	34·64	27·78					
		300	0·92	34·71	27·85					
		400	0·88	34·71	27·85	—	—	—	—	Moderate stray on wire

R.R.S. 'WILLIAM SCORESBY'
WHALE-MARKING CRUISE
STATIONS WS 896–922

27–28. xii. 1935—31. iii. 1936

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 896	63° 44′ S, 46° 26′ E	1935 27–28 xii	2200	—	NW × W	11–16	NW × W	2	cs	995·9	− 1·2	—	low av. swell
WS 897	62° 20·5′ S, 47° 23′ E	28 xii	2105	—	W × N	28–33	W × N	5	csq	992·4	0·5	0·1	low av. swell
WS 898	56° 30′ S, 46° 31·5′ E	1936 4 i	2045	—	ENE	11–16	ENE	3	od	990·9	1·3	1·1	mod. conf. swell
WS 899	59° 36′ S, 49° 11′ E	6 i	2130	—	SSE	4–6	SSE	1	b	988·0	0·00	− 1·2	mod. to heavy conf. swell
WS 900	60° 21′ S, 50° 34′ E	7 i	2107	—	N	11–16	N	3	bc	986·7	0·6	—	low long swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 896	2	0	−1·12	33·78	27·20	**N 100 B**	100–0	**0015**	**0035**	Depth estimated. −2 hours
		10	−1·12	33·81	27·22					
		20	−1·56	34·06	27·43					
		30	−1·73	34·21	27·56					
		40	−1·73	34·21	27·56					
		50	−1·68	34·23	27·56					
		60	−1·66	34·27	27·60					
		80	0·39	34·51	27·71					
		100	1·07	34·56	27·71					
		150	1·38	34·64	27·76					
		200	1·57	34·65	27·74					
		300	1·62	34·72	27·80					
		400	1·62	34·84	27·90					
WS 897	3	0	0·42	33·94	27·25	**N 100 B**	100–0	2213	2233	Depth estimated. −2 hours
		10	0·41	33·94	27·25					
		20	0·36	33·96	27·27					
		30	−0·65	33·98	27·34					
		40	−1·14	33·99	27·37					
		50	−1·42	34·05	27·42					
		60	−1·54	34·11	27·47					
		80	−1·64							
		100	−1·49	34·20	27·54					
		150	0·36	34·44	27·66					
		200	1·29	34·59	27·72					
		300	1·54	34·67	27·76					
		400	1·57	34·69	27·77					
WS 898	10	0	1·20	33·94	27·20	**N 100 B**	100–0	**2210**	**2230**	Depth estimated. −3 hours
		10	1·16	33·94	27·20					
		20	1·06	33·94	27·21					
		30	1·03	33·95	27·22					
		40	1·01	33·96	27·23					
		50	1·01	33·96	27·23					
		60	0·93	33·96	27·24					
		80	−0·04	33·98	27·31					
		100	−0·31	34·00	27·34					
		150	−0·14	34·14	27·44					
		200	0·86	34·38	27·58					
		300	1·46	34·55	27·68					
		400	1·72	34·64	27·73					
WS 899	12	0	0·56	33·84	27·16	**N 100 B**	100–0	**2245**	**2305**	Depth estimated
		10	0·54	33·85	27·17					
		20	0·26	33·85	27·19					
		30	0·08	33·85	27·20					
		40	0·03	33·85	27·20					
		50	0·03	33·85	27·20					
		60	−0·04	33·85	27·20					
		80	−1·64	33·95	27·34					
		100	−1·69	34·00	27·38					
		150	−0·17	34·25	27·53					
		200	1·11	34·48	27·64					
		300	1·77	34·63	27·72					
		400	1·85	34·68	27·75					
WS 900	13	0	1·01	33·86	27·14	**N 100 B**	100–0	**2213**	**2233**	Depth estimated
		10	0·46	33·87	27·19					
		20	0·32	33·80	27·14					
		30	0·06	33·83	27·19					
		40	0·01	33·86	27·20					
		50	−0·09	33·87	27·21					
		60	−1·55	33·99	27·38					
		80	−1·66	34·03	27·41					
		100	−1·14	34·14	27·48					
		150	1·01	34·46	27·63					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 900 *cont.*	60° 21′ S, 50° 34′ E	1936 7 i											
WS 901	62° 07′ S, 51° 37′ E	8–9 i	2350	—	E × N	4–6	E × N	1	os	987·5	0·1	—	conf. swell
WS 902	63° 35′ S, 53° 12′ E	17 i	2135	—	WSW	22–27	WSW	5	bcq	979·5	0·4	−0·3	mod. to heavy conf. swell
WS 903	65° 36′ S, 55° 12′ E	19 i	1050	—	W × N	48–55	W × N	1	bq	990·5	0·0	−0·6	low long swell
WS 904	63° 47′ S, 84° 16′ E	24 i	2105	—	W	7–10	W	2	o	999·2	0·5	−0·9	low av. swell
WS 905	61° 05′ S, 84° 17′ E	25 i	2210	—	W × N	11–16	W × N	2	os	998·2	1·1	0·7	low av. swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 900 *cont.*	13	200	1·53	34·56	27·67					
		300	1·82	34·66	27·73					
		400	1·82	34·69	27·75					
WS 901	14	0	0·33	33·91	27·23	N 100 B	100–0	0052	0112	Depth estimated
		10	0·28	33·94	27·26					
		20	0·16	33·95	27·27					
		30	−0·08	33·96	27·29					
		40	−0·24	33·97	27·31					
		50	−0·34	33·97	27·32					
		60	−1·49	34·05	27·42					
		80	−1·58	34·11	27·47					
		100	−0·94	34·22	27·53					
		150	0·96	34·50	27·66					
		200	1·37	34·62	27·75					
		300	1·62	34·69	27·77					
		400	1·58	34·70	27·79					
WS 902	23	0	0·05	33·61	27·01	N 100 B	115–0	2253	2313	Depth estimated
		10	0·05	33·61	27·01					
		20	0·05	33·60	27·00					
		30	−0·13	33·61	27·02					
		40	−0·18	33·66	27·05					
		50	−0·49	33·78	27·16					
		60	−1·54	34·08	27·45					
		80	−1·60	34·16	27·51					
		100	−1·59	34·16	27·51					
		150	0·35	34·42	27·63					
		200	1·32	34·52	27·66					
		300	1·53	34·60	27·70					
		400	1·60	34·68	27·77					
WS 903	25	0	−1·62	33·69	27·13	—	—	—	—	In pack ice
		10	−1·63	33·69	27·13					
		20	−1·64	33·76	27·19					
		30	−1·67	34·16	27·51					
		40	−1·72	34·24	27·59					
		50	−1·72	34·29	27·62					
		60	−1·72	34·33	27·65					
		80	−1·71	34·39	27·71					
		100	−1·70	34·39	27·71					
		150	−1·66	34·38	27·69					
		200	−1·69	34·43	27·73					
		300	−1·57	34·45	27·74	—	—	—	—	Moderate stray on wire
		400	−1·29	34·48	27·76					
WS 904	1	0	0·26	33·26	26·71	N 100 B	95–0	2210	2230	Depth estimated. −5 hours
		10	0·26	33·26	26·71					
		20	0·21	33·58	26·97					
		30	−0·67	33·77	27·16					
		40	−1·34	33·97	27·35					
		50	−1·54	34·12	27·48					
		60	−1·54	34·19	27·54					
		80	−1·45	34·29	27·61					
		100	−1·24	34·34	27·65					
		150	−1·14	34·41	27·70					
		200	−0·71	34·45	27·71					
		300	0·60	34·59	27·77					
		400	0·96	34·65	27·78					
WS 905	2	0	0·94	33·47	26·84	N 100 B	100–0	2325	2345	Depth estimated. −5 hours 30 minutes
		10	0·94	33·52	26·89					
		20	0·04	33·49	26·91					
		30	−0·54	33·78	27·17					
		40	−0·99	34·14	27·48					
		50	−0·94	34·15	27·49					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 905 *cont.*	61° 05′ S, 84° 17′ E	1936 25 i											
WS 906	59° 23′ S, 87° 26′ E	27 i	2055	—	NW × W	28–33	NW × W	6	cs	988·2	1·1	0·7	mod. short swell
WS 907	60° 40·5′ S, 100° 57′ E	8 ii	2005	—	E × N	11–16	E × N	3	ors	970·3	1·1	1·1	conf. swell
WS 908	62° 19′ S, 102° 13′ E	9 ii	2040	—	SSE	28–33	SSE	6	or	972·9	1·7	1·1	mod. short swell
WS 909	63° 27′ S, 103° 45′ E	10 ii	2020	—	SSE	7–10	SSE	2	ors	979·9	−0·6	−0·6	mod. av. swell
WS 910	64° 26′ S, 103° 54′ E	11 ii	2115	—	calm	< 1	—	1	bv	984·8	−5·0	−5·6	conf. swell

Station	Age of moon (days)	Hydrological observations: Depth (metres)	Temp. °C.	S ‰	σt	Biological observations: Gear	Depth (metres)	Time: From	To	Remarks
WS 905 *cont.*	2	60	−0·64	34·21	27·52					
		80	0·45	34·33	27·56					
		100	0·76	34·43	27·62					
		150	1·09	34·54	27·70					
		200	1·66	34·59	27·69					
		300	1·87	34·65	27·72					
		400	1·85	34·68	27·75					
WS 906	4	0	1·57	33·78	27·05	**N 100 B**	100–0	**2155**	**2215**	Depth estimated. −6 hours
		10	1·57	33·78	27·05					
		20	1·57	33·78	27·05					
		30	1·57	33·78	27·05					
		40	1·49	33·78	27·06					
		50	0·93	33·81	27·12					
		60	0·31	33·84	27·17					
		80	−0·34	33·95	27·30					
		100	−0·44	34·00	27·34					
		150	0·26	34·22	27·50					
		200	1·17	34·39	27·57					
		300	1·82	34·54	27·64					
		400	1·95	34·63	27·70					
WS 907	16	0	2·27	33·61	26·86	**N 100 B**	100–0	**2115**	**2135**	Depth estimated
		10	2·29	33·69	26·92					
		20	2·27	33·73	26·95					
		30	1·97	33·74	26·99					
		40	0·36	33·78	27·12					
		50	−0·64	34·00	27·35					
		60	−0·92	34·05	27·40					
		80	−1·03	34·15	27·49					
		100	−0·69	34·20	27·51					
		150	0·88	34·47	27·65					
		200	1·49	34·58	27·70					
		300	1·65	34·60	27·70					
		400	1·65	34·69	27·77					
WS 908	17	0	1·47	33·60	26·91	**N 100 B**	100–0	2045	2105	Depth estimated
		10	1·47	33·63	26·94					
		20	1·47	33·65	26·95					
		30	1·45	33·65	26·95					
		40	0·20	33·93	27·25					
		50	−0·74	34·07	27·41					
		60	−1·01	34·14	27·48					
		80	−1·12	34·30	27·61					
		100	0·76	34·53	27·71					
		150	1·47	34·60	27·71					
		200	1·57	34·64	27·74					
		300	1·55	34·67	27·76					
		400	1·57	34·70	27·79					
WS 909	18	0	1·08	33·55	26·90	**N 100 B**	95–0	2132	**2152**	Depth estimated
		10	1·09	33·52	26·88					
		20	1·15	33·59	26·93					
		30	−0·12	33·81	27·18					
		40	−1·06	34·17	27·51					
		50	−1·26	34·13	27·47					
		60	−1·42	34·25	27·58					
		80	−1·64	34·33	27·64					
		100	−1·66	34·52	27·80					
		150	−1·74	34·51	27·80					
		200	−1·72	34·43	27·74					
		300	−1·14	34·47	27·75					
		400	−0·27	34·58	27·80					
WS 910	19	0	−0·86	33·32	26·82	**N 100 B**	100–0	**2225**	**2245**	Depth estimated
		10	−0·74	33·38	26·85					
		20	−0·73	33·38	26·85					

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 910 *cont.*	64° 26′ S, 103° 54′ E	1936 11 ii											
WS 911	64° 49′ S, 103° 33′ E	12 ii	0945	—	E	17–21	E	3	cv	982·5	−5·0	−5·6	low long swell
WS 912	64° 40′ S, 79° 38′ E	22 ii	2035	—	S×W	11–16	S×W	2	csp	1007·1	−0·6	−1·8	low av. swell
WS 913	68° 45′ S, 70° 42′ E	24 ii	2100	549	S×W	34–40	S×W	5	os	996·0	−7·3	—	no swell
WS 914	67° 48′ S, 70° 41·5′ E	25 ii	1910	300	S×E	34–40	S×E	5	c	993·5	−5·6	−6·1	conf. swell
WS 915	64° 31′ S, 56° 06·5′ E	29 ii	2020	—	variable	4–6	—	1	c	993·3	−4·4	−5·0	conf. swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 910 *cont.*	19	30	−0·64	33·47	26·92					
		40	−1·14	33·81	27·22					
		50	−1·67	34·11	27·47					
		60	−1·72	34·34	27·66					
		80	−1·79	34·34	27·66					
		100	−1·80	34·34	27·66					
		150	−1·82	34·35	27·68					
		200	−1·82	34·13	27·49					
		300	−1·76	34·40	27·71					
		400	−1·24	34·48	27·76					
WS 911	19	—	—	—	—	**N 100 H**	10–5	0945	1005	In very young pancake ice, at edge of pack
WS 912	0	0	1·07	33·68	27·00	**N 100 B**	95–0	2125	2145	Depth estimated. −5 hours 30 minutes
		10	1·07	33·69	27·01					
		20	1·01	33·69	27·01					
		30	0·90	33·69	27·02					
		40	0·68	33·71	27·05					
		50	−1·02	34·15	27·49					
		60	−1·19	34·25	27·57					
		80	−0·86	34·36	27·65					
		100	−0·34	34·43	27·69					
		150	1·14	34·61	27·75					
		200	1·32	34·64	27·76					
		300	1·49	34·72	27·81					
		400	1·37	34·72	27·82					
WS 913	2	0	−0·56	33·96	27·32	—	—	—	—	−4 hours 30 minutes
		10	−0·56	34·01	27·36					
		20	−0·54	34·01	27·36					
		30	−0·54	34·01	27·36					
		40	−0·52	34·01	27·35					
		50	−0·46	34·02	27·36					
		60	−0·49	34·02	27·36					
		80	−1·24	34·35	27·66					
		100	−1·29	34·35	27·66					
		150	−1·74	34·42	27·72					
		200	−1·66	34·46	27·75	—	—	—	—	Moderate stray on wire
		300	−1·64	34·48	27·77					
		400	−1·74	34·51	27·80					
WS 914	3	0	−1·34	33·79	27·21	**N 100 B**	90–0	2009	2029	Depth estimated. −4 hours
		10	−1·34	33·78	27·20					
		20	−1·34	33·81	27·22					
		30	−1·34	33·92	27·31					
		40	−1·32	33·82	27·23					
		50	−1·32	33·83	27·24					
		60	−1·30	33·83	27·23					
		80	−1·32	33·87	27·26	—	—	—	—	} Moderately heavy stray on wire
		100	−1·34	33·91	27·30	—	—	—	—	
		150	−1·50	34·38	27·69					
		200	−1·77							
		300	−1·92	34·49	27·78	—	—	—	—	Touched bottom, sample muddy
WS 915	7	0	0·32	33·83	27·17	**N 100 B**	100–0	2125	2145	Depth estimated. −3 hours 30 minutes
		10	0·19	33·83	27·18					
		20	0·19	33·82	27·17					
		30	0·18	33·82	27·17					
		40	0·07	33·87	27·21					
		50	−0·38	33·86	27·22					
		60	−1·27	34·18	27·52					
		80	−1·24	34·28	27·60					
		100	−0·04	34·39	27·64					
		150	1·47	34·61	27·72					
		200	1·59	34·65	27·74					
		300	1·64	34·68	27·77					
		400	1·59	34·70	27·79					

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 916	63° 20′ S, 52° 33′ E	1936 2 iii	1930	—	NE × E	4–6	NE × E	1	c	990·2	−1·1	−1·7	conf. swell
WS 917	65° 55′ S, 51° 12′ E	5 iii	2035	219	E × S	17–21	E × S	2	bcv	975·3	−4·4	−5·0	low long swell
WS 918	64° 28′ S, 23° 04′ E	19 iii	2004	—	SE × S	1–3	SE × S	1	bc	981·6	−1·3	−2·8	conf. swell
WS 919	58° 37′ S, 22° 58′ E	25 iii	2036	—	N × W	22–27	N × W	5	od	981·9	0·1	—	mod. av. swell
WS 920	54° 46′ S, 20° 48′ E	27 iii	2040	—	SW	28–33	SW	5	o	987·5	1·1	—	conf. swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 916	9	0	0·43	33·86	27·18	**N 100 B**	95–0	**2025**	**2045**	Depth estimated. −3 hours
		10	0·43	33·87	27·19					
		20	0·42	33·87	27·19					
		30	0·40	33·87	27·19					
		40	0·38	33·88	27·21					
		50	0·09	33·90	27·24					
		60	−1·44	34·14	27·49					
		80	−1·64	34·18	27·53					
		100	−1·32	34·23	27·56					
		150	1·18	34·52	27·67					
		200	1·40	34·57	27·69					
		300	1·67	34·70	27·78					
		400	1·65	34·71	27·80					
WS 917	12	0	−1·68	33·69	27·13	**N 100 B**	100–0	**2135**	**2155**	Depth estimated
		10	−1·62	33·69	27·13					
		20	−1·59	33·69	27·13					
		30	−1·55	33·69	27·13					
		40	−1·54	33·69	27·13					
		50	−1·54	33·71	27·15					
		60	−1·54	33·71	27·15					
		80	−1·53	33·71	27·15					
		100	−1·46	33·73	27·16					
		150	−1·28	33·88	27·28					
		200	−1·24	34·03	27·40					
		220	−1·23	34·05	27·41					
WS 918	26	0	0·28	34·05	27·35	**N 100 B**	95–0	**2105**	**2125**	Depth estimated. −2 hours
		10	0·27	34·05	27·35					
		20	0·26	34·05	27·35					
		30	0·24	34·05	27·35					
		40	0·22	34·05	27·35					
		50	−0·63	34·14	27·46					
		60	−1·58	34·30	27·62					
		80	−1·32	34·34	27·65					
		100	0·06	34·52	27·74					
		150	1·16	34·65	27·77					
		200	1·19	34·65	27·77					
		300	1·27	34·68	27·79					
		400	1·18	34·73	27·84					
WS 919	3	0	0·66	33·77	27·09	**N 100 B**	95–0	**2147**	**2207**	Depth estimated
		10	0·66	33·78	27·10					
		20	0·66	33·78	27·11					
		30	0·66	33·79	27·12					
		40	0·66	33·79	27·12	—	—	—	—	
		50	0·65	33·79	27·12	—	—	—	—	
		60	0·64	33·78	27·12	—	—	—	—	
		80	0·56	33·79	27·13	—	—	—	—	
		100	−1·10	34·05	27·41	—	—	—	—	Moderate stray on wire
		150	−0·81	34·21	27·53	—	—	—	—	
		200	0·26	34·48	27·70	—	—	—	—	
		300	1·07	34·66	27·79	—	—	—	—	
		400	1·00	34·66	27·79	—	—	—	—	
WS 920	5	0	0·95	34·11	27·36					
		10	0·96	34·12	27·36					
		20	0·96	34·12	27·36					
		30	0·94	34·12	27·37					
		40	0·94	34·12	27·37	—	—	—	—	
		50	0·94	34·12	27·37	—	—	—	—	
		60	0·94	34·12	27·37	—	—	—	—	
		80	0·86	34·15	27·40	—	—	—	—	
		100	−0·21	34·33	27·59	—	—	—	—	Moderately heavy stray on wire
		150	−0·14	34·40	27·65	—	—	—	—	
		200	0·56	34·56	27·74	—	—	—	—	
		300	1·00	34·64	27·78	—	—	—	—	
		400	1·17	34·68	27·80	—	—	—	—	

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 921	46° 29′ S, 19° 07′ E	1936 30 iii	2035	—	W	11–16	W	3	0	1007·3	5·6	5·0	conf. swell
WS 922	43° 03′ S, 19° 04′ E	31 iii	2038	—	SW × S	17–21	SW × S	4	0	1019·5	8·8	7·3	mod. av. swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S °/₀₀	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 921	8	0	5·60	33·85	26·72					
		10	5·60	33·85	26·72					
		20	5·60	33·85	26·72					
		30	5·59	33·85	26·72					
		40	5·59	33·85	26·72					
		50	5·59	33·85	26·72					
		60	5·59	33·86	26·72					
		80	5·57	33·86	26·72					
		100	5·29	33·86	26·75					
		150	4·58	34·05	26·99					
		200	4·38	34·13	27·07					
		300	3·71	34·17	27·18					
		400	3·20	34·18	27·24					
WS 922	9	0	14·88	35·10	26·10					
		10	14·88	35·10	26·10					
		20	14·68	35·08	26·12					
		30	13·53	34·95	26·27					
		40	12·80	34·86	26·34					
		50	12·41	34·80	26·38					
		60	12·17	34·77	26·39					
		80	11·73	34·71	26·44					
		100	10·95	34·56	26·46					
		150	10·44	34·50	26·50	—	—	—	—	Heavy stray on wire
		200	10·20	34·46	26·51	—	—	—	—	
		300	9·69	34·52	26·65	—	—	—	—	
		400	9·16	34·57	26·77	—	—	—	—	

R.R.S. 'WILLIAM SCORESBY' WHALE-MARKING CRUISE STATIONS WS 923–937

7. xii. 1936—16. iii. 1937

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 923	56° 48′ S, 15° 35′ E (In large open pool inside pack ice)	1936 7 xii	1935	—	SW × W	11–16	SW × W	2	os	1000·8	−1·1	−1·2	low long swell
WS 924	58° 56′ S, 44° 30·5′ E	28 xii	2115	—	S × W	7–10	S × W	2	c	986·8	0·0	−0·6	low av. swell
WS 925	59° 27′ S, 51° 59′ E	30 xii	2007	—	S	17–21	S	4	hs-bc	993·5	0·0	—	conf. swell
WS 926	61° 08′ S, 63° 51′ E	1937 2 i	1907	—	WSW	17–21	WSW	5	orsp	998·3	−0·0	−1·1	low av. swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 923	24	0	−1·59	34·05	27·42	**N 100 B**	—	1950	2010	KT broken, depth unknown. −2 hours
		5	−1·59	34·03	27·41	**NHP**	50–0	2325	2333	NP bottle visible at 10 m.
		10	−1·59	34·04	27·41					
		20	−1·64	34·05	27·42					
		30	−1·64	34·05	27·42					
		40	−1·74	34·05	27·42					
		50	−1·74	34·06	27·43					
		60	−1·74	34·06	27·43					
		80	−1·74	34·12	27·49					
		100	−1·74	34·28	27·62					
		150	−1·64	34·33	27·64					
		200	−0·34	34·55	27·79					
		250	0·21	34·64	27·83					
		300	0·31	34·64	27·82					
		350	0·31	34·67	27·84					
		400	0·36	34·67	27·84					
WS 924	15	0	0·56	33·75	27·09	**N 100 B**	170–0	2123	2143	KT. −3 hours
		5	0·56	33·79	27·13	**NHP**	50–0	2320	2330	NP bottle visible at 5 m.
		10	0·46	33·78	27·12					
		20	−0·84	33·81	27·21					
		30	−0·84	33·88	27·27					
		40	−1·14	33·88	27·28					
		50	−1·49	33·97	27·36					
		60	−1·54	34·01	27·39					
		80	−1·69	34·07	27·44					
		100	−1·74	34·07	27·45					
		150	−1·74	34·12	27·49					
		200	0·97	34·46	27·63					
		250	1·57	34·60	27·70					
		300	1·67	34·69	27·76					
		350	1·67	34·60	27·69					
		400	1·77	34·68	27·76					
WS 925	17	0	0·36	33·81	27·15	**N 100 B**	132–0	2013	2033	KT. −4 hours
		5	0·36	33·82	27·16	**NHP**	50–0	2044	2051	NP bottle visible at 5 m.
		10	0·36	33·81	27·15					
		20	0·36	33·81	27·15					
		30	0·28	33·80	27·15					
		40	−0·34	33·81	27·19					
		50	−1·62							
		60	−1·64	34·06	27·43					
		80	−1·69	34·10	27·46					
		100	−1·69	34·12	27·48					
		150	−0·62	34·26	27·56					
		200	1·02	34·54	27·70					
		250	1·77	34·61	27·70					
		300	1·82	34·64	27·72					
		350	1·87	34·70	27·76					
		400	1·87	34·70	27·76					
WS 926	20	0	−0·56	33·41	26·88	**N 100 B**	170–0	1911	1931	KT
		5	−0·56	33·43	26·90	**NHP**	50–0	2111	2115	NP bottle visible at 10 m.
		10	−0·56	33·42	26·89					
		20	−0·59	33·43	26·90					
		30	−0·64	33·43	26·90					
		40	−0·64	33·58	27·01					
		50	−1·10	33·81	27·22					
		60	−1·55	33·87	27·28					
		80	−1·56	33·94	27·33					
		100	−1·59	33·95	27·34					
		150	−0·04	34·14	27·43					
		200	1·57	34·39	27·54					
		250	1·57	34·42	27·55					
		300	1·57	34·47	27·60					
		350	1·75	34·51	27·62	—	—	—	—	Big stray on wires
		400	1·92	34·61	27·70	—	—	—	—	

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 927	60° 47′ S, 68° 01′ E	1937 3 i	1943	—	W	11–16	W	3	o	994·4	0·0	−0·4	low av. swell
WS 928	60° 50′ S, 79° 28′ E	5 i	1914	—	WNW	7–10	WNW	2	c	988·0	0·0	−1·1	low conf. swell
WS 929	60° 54′ S, 95° 37′ E	22 i	2145	—	NE	4–6	N	1	o	986·2	1·2	1·1	low conf. swell
WS 930	62° 19′ S, 76° 07′ E	29 i	2110	—	N	4–6	N	1	o	984·2	2·5	1·1	low to mod. conf. swell
WS 931	62° 59′ S, 71° 09′ E	30 i	2142	—	ENE	22–27	ENE	5	os	974·0	1·1	0·6	mod. conf. swell
WS 932	63° 23′ S, 64° 40′ E	31 i	2145	—	SSE	4–6	SSE	2	c	985·9	2·1	1·0	mod. conf. swell
WS 933	64° 21′ S, 32° 32′ E	11 ii	2110	—	NE × E	17–21	NE × E	3	c	989·3	1·2	—	mod. conf. swell
WS 934	66° 36′ S, 09° 19′ E	10 iii	1735	—	variable	1–3	E	1	osp	980·0	−0·3	−0·5	low conf. swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S °/₀₀	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 927	21	0	−0·46	33·66	27·06	**N 100 B**	104–0	1946	2006	KT. −5 hours
		5	−0·45	33·65	27·06	**NHP**	50–0	2018	2023	NP bottle visible at 10 m.
		350	1·92	33·64	27·72					
		400	2·02	33·68	27·74					
WS 928	23	0	0·38	33·98	27·29	**N 100 B**	157–0	1917	1937	KT
		5	0·39	33·98	27·29	**NHP**	50–0	2103	2109	NP bottle visible at 5 m.
		10	0·39	33·98	27·29					
		20	0·37	33·98	27·29					
		30	0·36	33·99	27·30					
		40	−0·14	34·00	27·33					
		50	−0·94	34·10	27·44					
		60	−1·09	34·20	27·53					
		80	0·20	34·38	27·62					
		100	0·77	34·44	27·64					
		150	1·67	34·58	27·68					
		200	1·75	34·61	27·71					
		250	1·84	34·65	27·72					
		300	1·87	34·65	27·72					
		350	1·92	34·69	27·74					
		400	1·92	34·70	27·75					
WS 929	11	0	2·17	33·85	27·06	**NHP**	50–0	**2227**	**2232**	−6 hours
WS 930	17	0	2·52	33·77	26·96	**N 100 B**	159–0	**2116**	**2136**	KT. −5 hours
		5	2·39	33·77	26·97	**NHP**	50–0	**2318**	**2325**	
		10	1·72	33·79	27·05					
		20	1·27	33·84	27·12					
		30	0·66	33·89	27·19					
		40	−0·24	33·99	27·33					
		50	−1·22	34·00	27·37					
		60	−1·24	34·13	27·47					
		80	−0·80	34·28	27·59					
		100	−0·32	34·35	27·63					
		150	1·27	34·89	27·96					
		200	1·57	34·88	27·93					
		250	1·89	34·68	27·75					
		300	1·92	34·68	27·74					
		350	1·92	34·68	27·74					
		400	1·92	34·77	27·81					
WS 931	18	0	1·37	33·69	26·99	**N 100 B**	121–0	**2149**	**2210**	KT
WS 932	19	0	1·39	33·66	26·96	**N 100 B**	108–0	**2157**	**2217**	KT. −4 hours
		5	1·37	33·66	26·96	**NHP**	50–0	**2230**	**2235**	
		10	1·37	33·65	26·96					
		20	1·17	33·67	26·98					
		30	−0·54	33·89	27·26					
		40	−1·19	34·05	27·41					
		50	−1·52	34·14	27·49					
		60	−1·51	34·15	27·51					
		80	−0·41	34·31	27·59					
		100	0·41	34·41	27·63					
		150	1·67	34·59	27·69					
		200	1·77							
		250	1·87	34·65	27·72					
		300	1·87	34·69	27·75					
		350	1·87	34·69	27·75					
		400	1·87	34·69	27·75					
WS 933	1	0	1·07	33·77	27·07	**N 100 H**	5–0	**2110**	**2130**	−2 hours
WS 934	27	0	0·61	34·14	27·40	**N 100 B**	135–0	1744	1803	KT
		5	0·64	34·34	27·56	**NHP**	50–0	1938	1945	
		10	0·58	34·14	27·41					
		20	0·58	34·14	27·41					

Station	Position	Date	Hour	Sounding (metres)	WIND		SEA		Weather	Barometer (millibars)	Air Temp. °C.		Remarks
					Direction	Force (knots)	Direction	Force			Dry bulb	Wet bulb	
WS 934 *cont.*	66° 36′ S, 09° 19′ E	1937 10 iii											
WS 935	64° 07′ S, 09° 58′ E	12 iii	2100	—	W	4–6	W	2	c	987·2	−1·6	—	low conf. swell
WS 936	60° 56′ S, 10° 18′ E	15 iii	1315	—	E×S	17–21	E×S	4	os	960·4	0·9	0·6	low conf. swell
WS 937	57° 42′ S, 10° 17′ E	16 iii	2110	—	SW×S	22–33	SW×S	4–5	ors	961·6	1·3	0·8	conf. swell

Station	Age of moon (days)	HYDROLOGICAL OBSERVATIONS				BIOLOGICAL OBSERVATIONS				Remarks
		Depth (metres)	Temp. °C.	S ‰	σt	Gear	Depth (metres)	TIME From	TIME To	
WS 934 *cont.*	27	30	0·56	34·14	27·40					
		40	0·56	34·14	27·40					
		50	0·56	34·14	27·40					
		60	−1·34	34·41	27·71					
		80	−0·70	34·55	27·80					
		100	−0·04	34·58	27·79					
		150	0·48	34·65	27·81					
		200	0·56	34·68	27·84					
		250	0·56	34·67	27·83					
		300	0·61	34·67	27·83					
		350	0·71	34·68	27·83					
		400	0·77	34·69	27·83					
WS 935	0	0	1·27	34·11	27·33	N 100 B	106–0	2110	2130	KT
		5	1·27	34·10	27·32	NHP	50–0	2143	2150	
		10	1·27	34·11	27·33					
		20	1·27	34·13	27·34					
		30	1·27	34·11	27·33					
		40	0·77	34·14	27·39					
		50	−0·97	34·37	27·66					
		60	−1·14	34·40	27·69					
		80	−0·54	34·48	27·74					
		100	0·11	34·55	27·76					
		150	0·97	34·64	27·78					
		200	1·17	34·69	27·80					
		250	1·19	34·69	27·80					
		300	1·12	34·70	27·81					
		350	1·07	34·69	27·81					
		400	1·02	34·70	27·83					
WS 936	3	0	1·27	33·82	27·11	N 100 B	146–0	1327	1347	KT
		5	1·30	33·82	27·10	NHP	50–0	1513	1520	
		10	1·31	33·84	27·11					
		20	1·35	33·88	27·15					
		30	−1·58	34·18	27·53					
		40	−1·66	34·18	27·53					
		50	−1·71	34·19	27·54					
		60	−1·69	34·21	27·55					
		80	−1·69	34·34	27·67					
		100	−1·64	34·36	27·67					
		150	0·95	34·65	27·78					
		200	1·07	34·68	27·81					
		250	1·12	34·70	27·81					
		300	1·07	34·70	27·83					
		350	1·02	34·71	27·84					
		400	0·99	34·71	27·84					
WS 937	4	0	0·87	33·86	27·15	N 100 B	182–0	2120	2144	Depth estimated
		5	0·89	33·85	27·15	NHP	50–0	2210	2218	
		10	0·89	33·86	27·15					
		20	0·88	33·86	27·15					
		30	0·87	33·86	27·15	—	—	—	—	Full series abandoned in rising gale

R.R.S. 'WILLIAM SCORESBY' WHALE-MARKING CRUISE STATIONS WS 938–959

25. x. 1937—23. ii. 1938

Station	Position	Date	Hour	Sounding (metres)	WIND Direction	WIND Force (knots)	SEA Direction	SEA Force	Weather	Barometer (millibars)	Air Temp. °C. Dry bulb	Air Temp. °C. Wet bulb	Remarks
WS 938	46° 27′ S, 35° 11′ W	1937 25 x	1930	—	N	11–16	NW	3	c	1012·2	7·8	7·2	low av. NW swell
WS 939	49° 01′ S, 32° 16′ W	30 x	2000	—	WSW	7–10	SW	1	o	1001·1	3·8	2·7	low long SW swell
WS 940	54° 36′ S, 30° 46′ W	14 xi	2102	—	NW	11–16	NW	3	b	999·3	0·4	0·3	mod. short NW swell
WS 941	55° 19′ S, 27° 06′ W	16 xi	2022	—	NW	17–21	NW	4	c	994·8	0·7	0·6	low av. NW swell
WS 942	56° 40′ S, 21° 53′ W	18 xi	2055	—	E × S	17–21	E × S	4	o	976·9	−3·3	−3·5	mod. short E swell
WS 943	56° 57′ S, 17° 21′ W	20 xi	2057	—	ESE	17–21	ESE	3	o	997·8	−3·3	−5·1	low long NNE swell
WS 944	56° 46′ S, 20° 31′ W	23 xi	2020	—	NW	22–27	NW	4	o	1014·2	0·0	−0·6	low av. NW swell
WS 945	57° 21′ S, 24° 17′ W	26 xi	2121	—	WNW	22–27	WNW	4	o	981·8	−0·5	−0·6	low av. NW swell
WS 946	56° 31′ S, 12° 28′ W	9 xii	2100	—	NW × N	11–16	NW × N	3	o	1008·1	0·6	0·5	mod. long W swell
WS 947	57° 22′ S, 10° 09′ W	10 xii	2035	—	NW	22–27	NW	4	o	993·7	−0·1	−0·4	mod. av. NW swell
WS 948	56° 24′ S, 02° 10′ W (In vicinity of drift and pack ice)	15 xii	2130	—	W	28–33	W	3	o	989·0	0·0	−0·5	mod. long WNW swell
WS 949	59° 29′ S, 20° 25′ W	27 xii	2125	—	NW	7–10	NW	3	om	981·4	−0·4	−0·4	low av. conf. NW swell
WS 950	61° 21′ S, 46° 43′ W	1938 14 i	2253	—	SSW	17–21	SSW	3	osq	995·2	−2·4	−3·3	low av. SW swell
WS 951	68° 26′ S, 81° 23′ W	25 i	1100	—	ENE	11–16	ENE	3	f	965·9	1·1	1·1	heavy av. NE swell
WS 952	67° 06′ S, 82° 52′ W	28 i	0925	—	E	1–3	E	2	fe	961·1	0·8	0·8	mod. short E × N swell
WS 953	66° 17′ S, 74° 54′ W	29 i	2000	—	NNE	11–16	N × E	3	odm	972·4	2·1	2·1	low long WNW swell
WS 954	65° 03′ S, 69° 03′ W	31 i	2130	—	W	7–10	W	3	o	977·5	1·7	1·1	mod. av. W swell
WS 955	67° 06′ S, 72° 30′ W	15 ii	2246	—	SSE	11–16	SSE	3	c	990·2	−1·7	−2·2	mod. av. NE swell
WS 956	65° 37′ S, 68° 52′ W	18 ii	2200	—	NW × N	7–10	NNW	2	c	1000·5	0·6	0·0	low av. NW swell
WS 957	62° 24′ S, 57° 23′ W	21 ii	2030	—	W	11–16	W	3	bc	980·1	1·6	1·1	low av. N swell
WS 958	60° 32′ S, 56° 54′ W	22 ii	2006	—	WSW	22–27	WSW	4	or	979·5	2·2	2·1	heavy av. WNW swell
WS 959	58° 15′ S, 57° 41′ W	23 ii	2004	—	N	4–6	N	2	c	992·4	3·4	2·9	mod. av. WNW swell

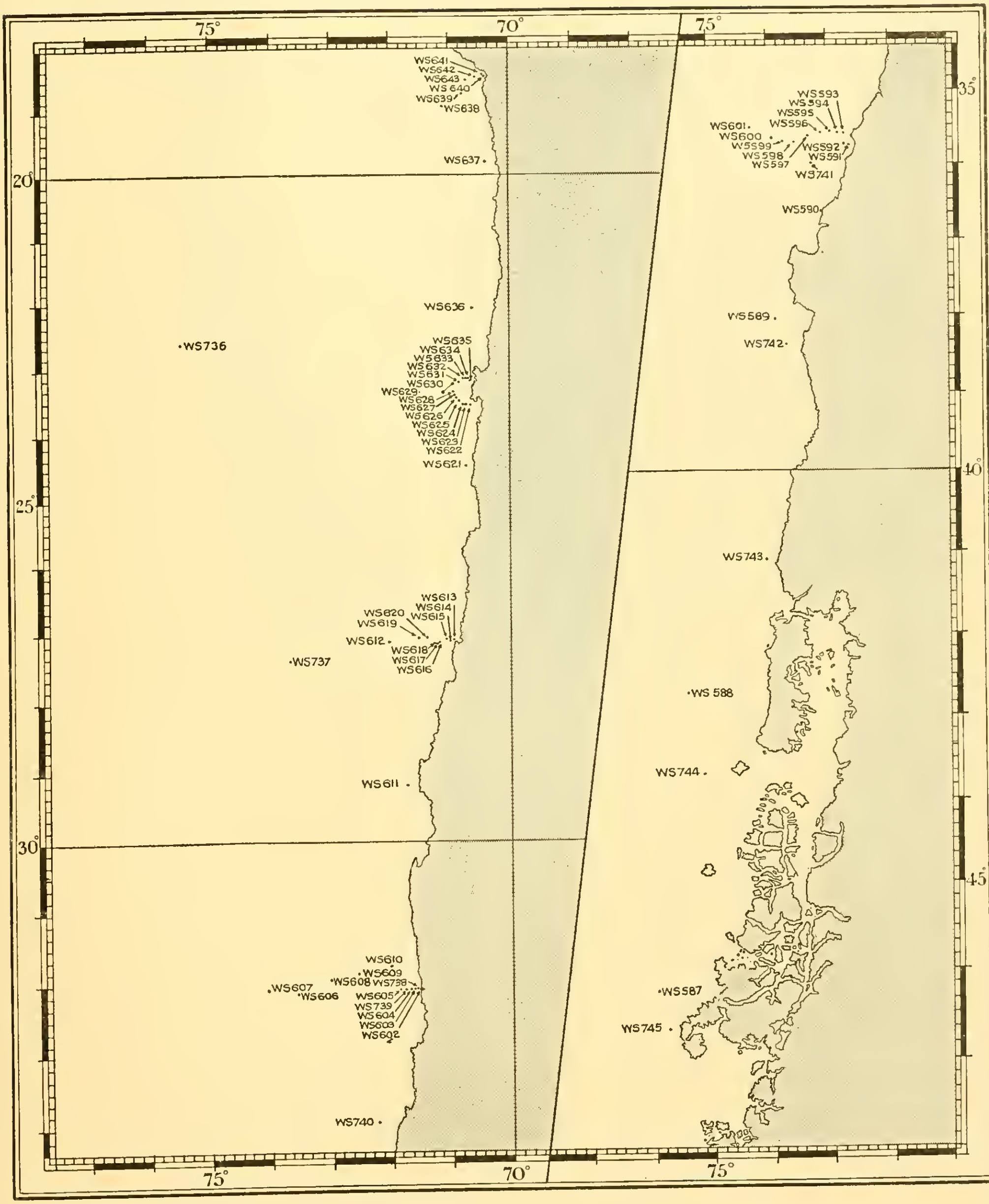
Station	Age of moon (days)	Hydrological observations			Biological observations				Remarks
		Depth (metres)	Temp. °C.	S ‰	Gear	Depth (metres)	Time From	Time To	
WS 938	21	—	7·2	—	N 100 B	83–0	2006	2026	KT. +2 hours
WS 939	26	—	6·7	—	N 100 B	88–0	2011	2031	KT
WS 940	12	—	0·8	—	N 100 B	156–0	2115	2135	KT. +1 hour
WS 941	14	—	1·1	—	N 100 B	100–0	2040	2100	KT
WS 942	16	—	−1·2	—	N 100 B	122–0	2111	2131	KT
WS 943	18	—	−2·2	—	N 100 B	77–0	2112	2132	KT
WS 944	21	0	0·0	33·99	N 100 H	10–0	2025	2045	Streamed on rope. Hauled by hand
WS 945	24	0	−0·1	34·10	N 100 B	104–0	2126	2146	KT
WS 946	7	0	0·4	33·81	N 100 B	122–0	2110	2130	KT
WS 947	8	0	−0·6	33·67	N 100 H	5–10	2050	2057	
WS 948	13	0	−0·7	33·99	N 100 B	70–0	2138	2158	KT. GMT
WS 949	25	0	−0·1	33·59	N 100 B	94–0	2140	2200	KT. +1 hour
WS 950	13	—	0·6	—	N 100 H	0–5	2301	2306	+ 3 hours
WS 951	24	0	0·6	33·78	N 100 B	137–0	1106	1126	KT. +5 hours
WS 952	27	0	1·1	33·75	N 100 B	90–0	0933	0954	KT
WS 953	28	0	2·2	33·74	N 100 B	95–0	2007	2027	KT
WS 954	0	0	2·1	33·45	N 100 B	100–0	2148	2208	Depth estimated
WS 955	15	0	1·1	33·71	N 100 B	112–0	2307	2327	KT. +4 hours
WS 956	18	0	1·0	33·31	N 100 B	86–0	2209	2229	KT
WS 957	21	0	1·1	34·08	N 100 B	91–0	2042	2102	KT
WS 958	22	0	2·2	33·93	N 100 B	177–0	2014	2034	KT. Towing against very heavy swell
WS 959	23	0	3·3	33·89	N 100 B	90–0	2010	2030	KT

SUMMARIZED LIST OF STATIONS

The positions of all stations made by the R.R.S. 'William Scoresby' between April 1931 and February 1938 are shown on the charts reproduced in Plates XXXIV–XXXVII. The following list indicates on which chart each of the stations is to be found.

Station	Date	Place	Plate
WS 576	17. iv. 31	Falkland Islands	XXXVI
WS 577–579	20. iv–22. iv. 31	Falkland Islands—Magellan Strait	XXXVI
WS 580–585	23. iv.–4. v. 31	Magellan Strait	XXXVI
WS 586	8. v. 31	Off southern coast of Chile	XXXVII
WS 587–590	10. v.–16. v. 31	Off southern coast of Chile	XXXIV
WS 591–643	18. v.–19–20. vi. 31	Peru Current Survey	XXXIV
WS 644–735	20. vi.–23. viii. 31	Peru Current Survey	XXXV
WS 736–741	25. viii.–4. ix. 31	Peru Current Survey	XXXIV
WS 742–745	5. ix.–10. ix. 31	Off southern coast of Chile	XXXIV
WS 746–749	16. ix.–18. ix. 31	Magellan Strait	XXXVI
WS 750–755	19. ix.–21. ix. 31	Magellan Strait—Falkland Islands	XXXVI
WS 756–878	10. x. 31–4. iv. 32	Trawling Survey, Patagonian Shelf	XXXVI
WS 879–882	5. iv–19. iv. 32	Falkland Islands—Monte Video	XXXVI
WS 883–895	31. xii. 34–20. ii. 35	Whale-marking Cruise	XXXVII
WS 896–922	27–28. xii. 35–31. iii. 36	Whale-marking Cruise	XXXVII
WS 923–937	7. xii. 36–16. iii. 37	Whale-marking Cruise	XXXVII
WS 938–959	25. x. 37–23. ii. 38	Whale-marking Cruise	XXXVII

PLATES XXXIV—XXXVII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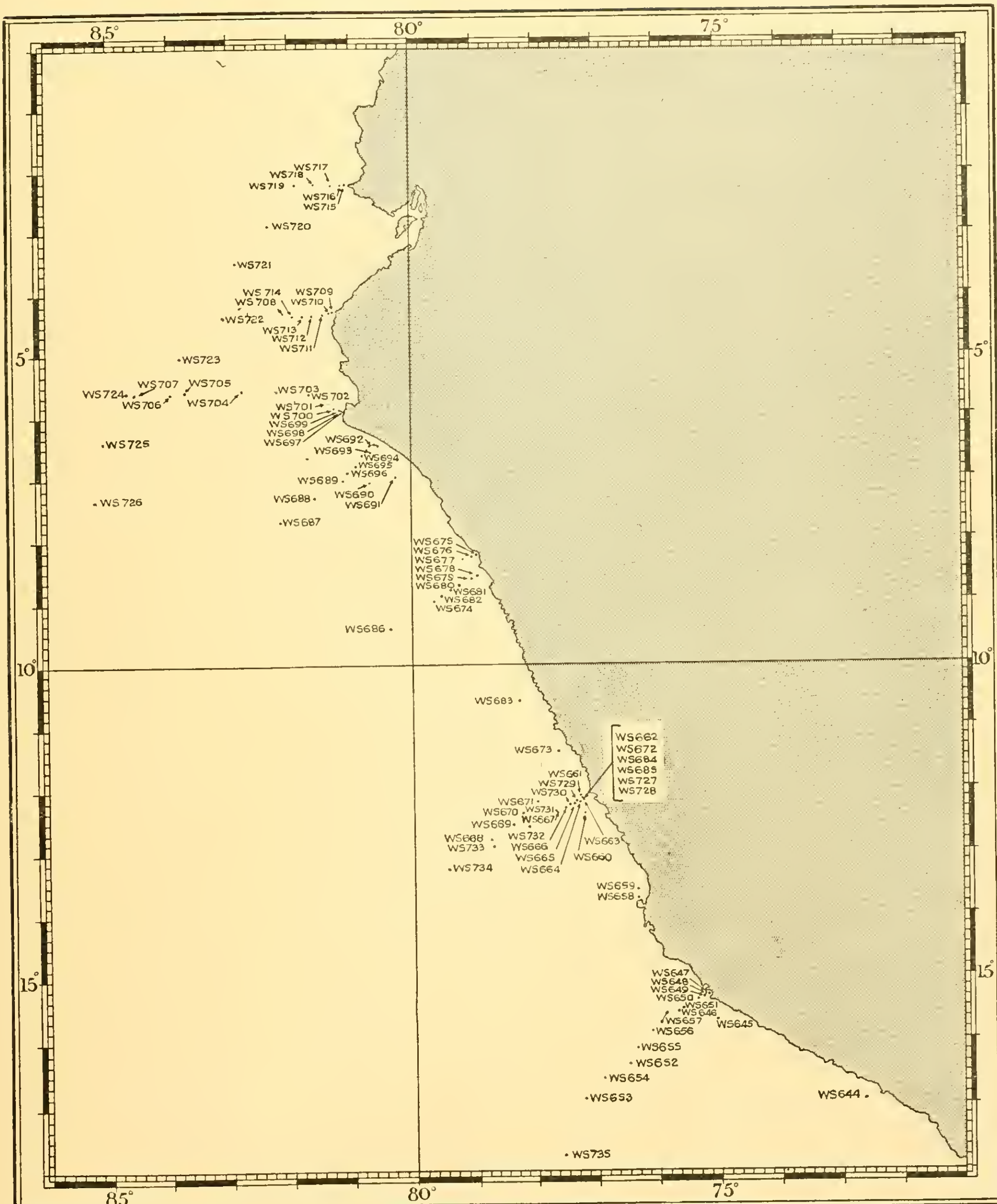
WS745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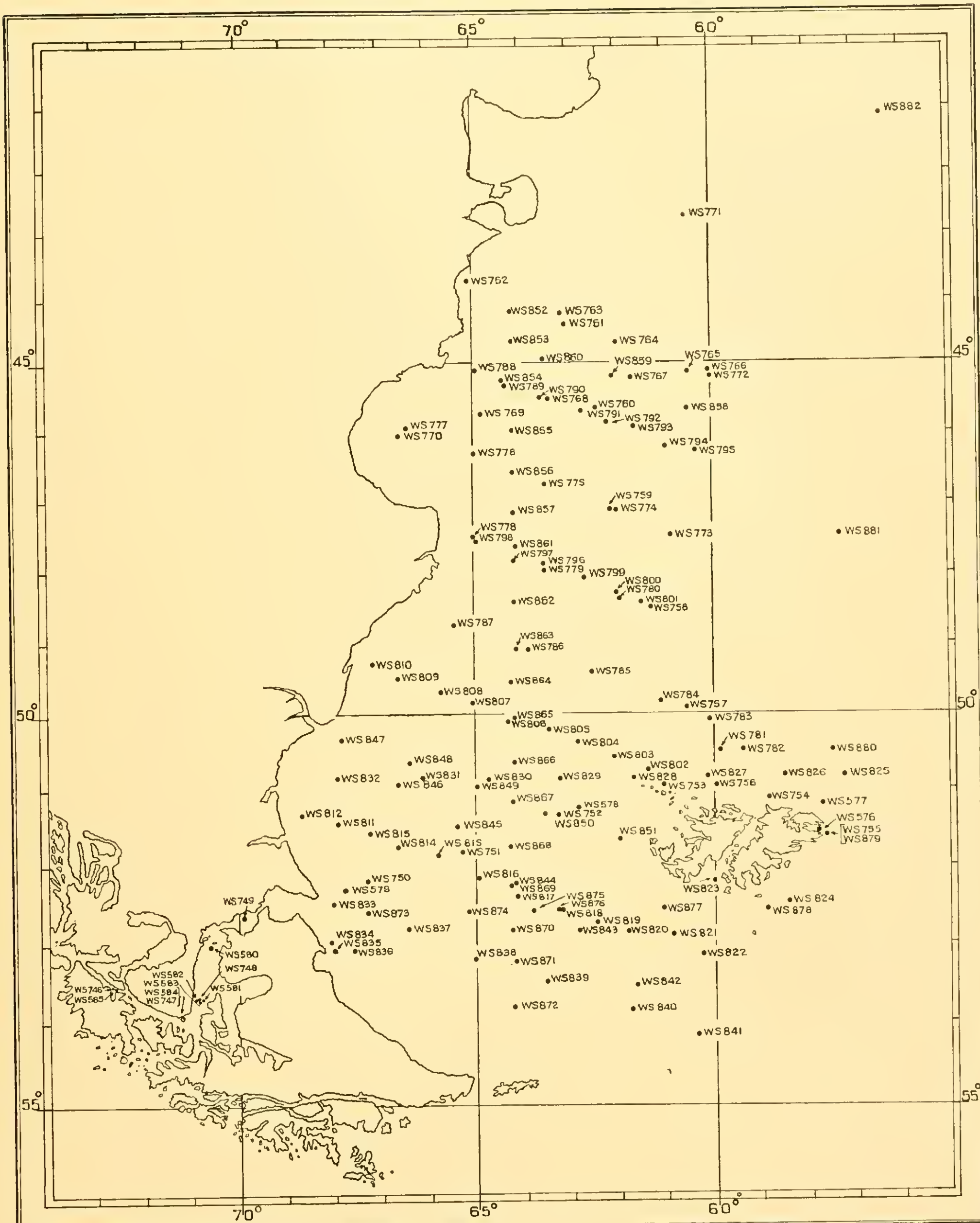
WS735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WS908
WS909
WS950
WS959
WS958
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WS952

ELLOBIOPSIDAE

By Dr H. Boschma, F.M.L.S., C.M.Z.S.
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(Plates XXXVIII–XLI; Text-figs. 1–16)

INTRODUCTION

The material of the parasitic Protozoa, Ellobiopsidae, in the Discovery collections is interesting, as it contains specimens of three of the larger species of the family, all belonging to the genus *Amallocystis*. As the material was in an excellent state of preservation, a comparative study could be made of the organ of fixation and the parts of the organism which obviously serve for the absorption of food. The rather complicated structure of these parts in two of the species found its explanation in the more simple arrangement occurring in the third species.

The collection contains abundant material of a parasite of various Euphausiacea, described in a short preliminary note (Boschma, 1948) as *A. fagei*. There are previous records of this species, but until recently it remained unnamed.

The new species *A. umbellatus* described in the present paper is the first of the genus to become known as a parasite of Caridea of the family Hoplophoridae. In the collection there are two specimens, one of which was studied in more detail.

Finally, the collection contains two specimens of *A. capillosus* Fage, a parasite of Caridea of the genus *Pasiphaea*, hitherto known from the Skagerrak only. The specimens described here are from the Strait of Magellan.

I am much obliged to Dr L. B. Holthuis for determining the sex of the specimens of *Hoplophorus* and of *Pasiphaea* infested with *Amallocystis*. Moreover, I am much indebted to Dr N. A. Mackintosh for his care in editing the present paper.

REVIEW OF THE LITERATURE OF THE ELLOBIOPSIDAE

Sars (1868). Description and figure of parasitic bodies on the third maxillipede and the two preceding appendages of *Pasiphaea multidentata* Esmark (*P. norvegica* M. Sars). Their shape was reminiscent of the Gregarinids; the smaller specimens consisted of a cylindrical sac with rounded free extremity, and the larger specimens consisted of two sacs, one on the top of the other. The distal sac was smaller and thinner than the proximal, the latter often being thicker in its upper than in its lower part. It is not improbable that these parasitic bodies were Ellobiopsidae consisting of a trophomere which could give rise to one gonomere. They remind one of *Ellobiocystis tenuis* Coutière, 1911*c*, parasitic on *Pasiphaea sivado* (Risso).

Bate (1888). To the description of his new species *P. cristata* from St. 173 of the Challenger Expedition (off the Fiji Islands, 315 fathoms) this author adds: 'In our specimen, which I consider to be a female, there is a mass of parasitic cell-growth (fig. 3) strung together in a bead-like arrangement and suspended from a common centre' (loc. cit., p. 869). The figures (loc. cit., pl. cxl, figs. 1, 3 and 3′) show that the parasite is attached to the ventral surface of the second abdominal segment; it consists of groups of trophomeres, each bearing two or three gonomeres. In the most highly enlarged figure there are visible the remains of recently detached gonomeres.

Scott (1897). Drawing of a specimen of *Calanus finmarchicus* (Gunn.) found in the Clyde, up as far as the head of Loch Fyne, with an 'Infusorian-like' parasite. The author adds: 'the parasites are found adhering to the body of the copepods, to the antennules, to the antennae, and to other appendages, but usually about the head; sometimes large numbers of *Calanus* will be found infested by these parasites.' The figure shows a parasite with a comparatively long stalk. The body is divided into a smaller proximal part and a larger distal part, just as in *Ellobiopsis chattoni* described by Caullery (1910).

Mrázek (1902). Numerous specimens of *Calanus finmarchicus* from the Spitzbergen region of the Arctic Sea showed large short-stalked 'cysts of some Ciliate' on the antennulae or on the maxillipedes or on the thorax. Mrázek was convinced that these cysts were the same as the parasites mentioned and figured by Scott (1897).

Caullery (1910). Description of *Ellobiopsis chattoni*, a parasite of *Calanus helgolandicus* Claus from Banyuls-sur-mer. The parasites are attached by means of a stalk to the mouthparts, maxillipedes, and antennae of the copepod. Young stages are oval or globular; older stages show a division of the body in two parts, a smaller trophomere and a larger gonomere. The stalk penetrates into the appendage of the host. Caullery is convinced that this stalk is not only an organ of fixation, but also an organ for the absorption of food from the host. The systematic position of the parasite is discussed, and there are indications which point to its being allied to the Peridinians, which are known to contain a number of parasitic forms. In a postscript Caullery adds that Mrázek drew his attention to the similarity of *Ellobiopsis* to the parasites mentioned by Scott (1897). Material afterwards received from Scott proved the identity of the two forms.

Apstein (1911). Notes on 'Parasit 19' occurring on *Pseudocalanus*, *Calanus* and *Acartia*; as a rule on the antennae. The figures represent one undivided specimen and one with distinct trophomere and gonomere. The more or less globular gonomere is about half as large as the slightly elongate trophomere.

Coutière (1911 *a*). Short description of parasites occurring on *Parapasiphaë grimaldii* Coutière (not mentioned in later papers by the same author as a host of Ellobiopsidae), *Acanthephyra purpurea* A.M.E. and *A. pulchra* A.M.E., similar to *Ellobiopsis chattoni* Caullery. These parasites do not show a transverse septum (no division in trophomere and gonomere); they are attached to their hosts by simple broadening of their proximal extremity, without penetrating the appendage of the host.

Coutière (1911 *b*). Remarks that specimens of *Ellobiopsis* were found by him on *Systellaspis debilis* (A.M.E.), *Acanthephyra pulchra* A.M.E. and *A. purpurea* A.M.E. To these parasites the common name *Ellobiopsis caridarum* is given, though there are five forms of probably specific distinction. The most common form, indicated as α, is ovoid or elongate, without stalk; β is a swollen form with a long stalk originating from a broad circular base; γ is a slightly conical form with broad base of attachment, and its cuticle is covered with soft hairs; ϵ is a form consisting of two successive cylindrical elements; η is a form with short spherical elements. Consequently in ϵ and η the body is divided into trophomere and gonomere, whereas in the other forms no such division was observed.

In the same paper an Ellobiopsid is described consisting of about fifty cylindrical bodies, united on a common stalk, the cylindrical bodies up to 4 mm. long, each divided into two to eight elements. The stalk penetrates the abdominal wall of the host, *Pasiphaea tarda* Kröyer, and ends with a blunt point in the connective tissue under the ventral nerve cord. Coutière names this organism, which he regards as a real parasite, *Ellobiopsis racemosus*.

Chatton (1911). Points to the similarity of Apstein's parasite 19 with *E. chattoni* Caullery and the parasite found by Scott on *Calanus finmarchicus* (Gunn.).

Coutière (1911 *c*). More elaborate data on the Ellobiopsidae dealt with in previous papers (Coutière,

1911*a*, *b*). Genus *Staphylocystis*, type *Ellobiopsis racemosus* Coutière; genus *Ellobiocystis*, type *Ellobiopsis caridarum* Coutière. The author distinguishes the following species:

Staphylocystis racemosus, on the ventral surface of the third abdominal segment of *Pasiphaea tarda* Kröyer, from St. 1038 of the cruises of the 'Princesse-Alice', north-east of Iceland, 3310 m. According to Coutière the parasite described by Bate on *P. cristata* Bate from the Fiji Islands belongs to this species.

In the genus *Ellobiocystis* Coutière recognizes a number of species. The hosts were collected during the cruises of the 'Princesse-Alice' in the region of the Bay of Biscay to the Azores from depths up to 5000 m. (except *E. mysidarum*). The species chiefly occur on the mouthparts and the maxillipedes of the hosts. The names given by Coutière are:

Ellobiocystis caridarum, on *Acanthephyra purpurea* A.M.E., *A. pulchra* A.M.E. and *Systellaspis debilis* (A.M.E.).

Ellobiocystis villosus (forme γ of 1911*b*), on *Acanthephyra purpurea* A.M.E.

Ellobiocystis tuberosus (forme η of 1911*b*), on *Acanthephyra purpurea* A.M.E.

Ellobiocystis filicollis (forme β of 1911*b*), on *Acanthephyra purpurea* A.M.E.

Ellobiocystis catenatus (forme ϵ partim of 1911*b*), on *Acanthephyra purpurea* A.M.E.

Ellobiocystis tenuis (forme ϵ partim of 1911*b*), on *Pasiphaea sivado* (Risso).

Ellobiocystis mysidarum, on *Antarctomysis maxima* (H. J. Hansen, MS. in Holt and Tattersall) from the Antarctic (the French Antarctic Expedition of the 'Pourquoi-Pas?').

Finally, Coutière mentions small parasites of *Sergestes* sp., from the cruises of the 'Princesse-Alice', in all probability belonging to *Ellobiocystis caridarum*.

Caullery (1912). Short note on the particulars and the systematic position of *Ellobiopsis chattoni*, abstract of a paper read at the Congress of Zoology of 1910.

Lühe (1912). In the discussion following the paper by Caullery, Lühe remarked that he had found on the gills of a Unionid parasites which were extraordinarily similar to those described by Caullery. No further data being available, it is impossible to decide whether or not these parasites belonged to the Ellobiopsidae.

Collin (1913). Description of *Parallobiopsis coutieri*, parasite of *Nebalia bipes* (O. Fabr.). The parasite is attached to the abdominal appendages, the gills, and especially to the membranous folds of the cephalothorax of the host. It is fixed to the chitin by a circular sucker, and according to Collin it has no root system ('il n'émet point de rhizoïdes'). In young stages the body already shows a transverse septum; in older stages up to nine successive gonomeres may be observed, and the topmost may show the remnants of a former gonomere from which the spores have escaped.

Chatton (1920). This extensive paper was completed in May 1914; it gives, besides data on real parasitic Peridinea, the most important particulars of the Ellobiopsidae. Concerning the species distinguished by Coutière in his genus *Ellobiocystis*, Chatton remarks that a specimen of *E. caridarum* (Coutière, 1911*c*, pl. viii, fig. 18) in its lower half shows hairs, as they occur as a specific character in *E. villosus*. This causes some doubt concerning the specific status of the various forms.

Willey (1920). Figure and notes of a 'two-chambered cyst' attached to the right antenna of a female of *Pseudocalanus elongatus* (Boeck) from Collinson point (Camden bay), Arctic Alaska, 1–2 fathoms, similar to the parasites observed by Scott (1897), now named *Ellobiopsis chattoni* Caullery. In the trophomere and in the gonomere a faint indication of a radial arrangement of the contents was observed. The shape of Willey's specimen differs from Caullery's specimens of *E. chattoni* in so far as the more or less conical trophomere is much larger than the globular gonomere.

Zachs (1923). Description and figure of *E.* (?) *eupraxiae* on the parapodia of the Polychaete worm *Nephthys ciliata* Müller from the White Sea. The parasite consists of an elongately oval trophomere and

one to five globular gonomeres. In the figured specimen spores are emerging from the top of the distal gonomere. The parasite penetrates into the host by means of a more or less dichotomously divided root system.

Hovasse (1925*a*). The spores of *Parallobiopsis coutieri* Collin are flagellispores, not dinospores as might have been expected on the presumption that the Ellobiopsidae are allied to the Peridinea.

Hovasse (1925*b*). Cytological studies of the cycle of evolution of *P. coutieri*.

Hovasse (1926). Extensive studies of living and preserved material of *P. coutieri*. The author shows that this organism is a real parasite, as in the centre of the sucker with which it is attached to the host the cuticle of the latter shows an opening through which a protoplasmatic mass of the parasite penetrates into the tissues underlying the cuticle, thereby forming an organ for the absorption of food. As far as concerns the systematic position of the Ellobiopsidae, Hovasse remarks that they form a special group in the class Flagellata. The form described by Zachs as *Ellobiopsis eupraxiae*, according to Hovasse must be the type of a separate genus, on account of its divided root system. Hovasse proposes for this genus the name *Rhizellobiopsis*; he remarks that the shape of this parasite corresponds with *Staphylocystis* in so far as it bears more than one gonomere on the top of its trophomeres.

Macdonald (1927). Among the parasites of *Meganyctiphanes norvegica* (M. Sars) this author notes: '*Staphylocystis racemosus* (Coutière), a dinoflagellate found on the carapace of a specimen caught at "Cumbrae Deep" in March 1925. The only record of this parasite is that of Kröyer on *Pasiphaea tarda* in N.E. Iceland' (loc. cit., p. 780). Instead of 'Kröyer', read 'Coutière'; the type specimen of Coutière's *Staphylocystis racemosus* is from north-east Iceland. In all probability, however, the identification of the parasite is incorrect. It is stated to occur 'on the carapace', and, therefore, almost certainly belongs to *Amallocystis fagei* dealt with in the present paper. Support to this opinion is, moreover, given by the fact that the host is a Euphausiid. The hitherto known Ellobiopsidae of this group of Crustacea belong to the species *A. fagei*.

Steuer (1928). Notes on *Ellobiopsis chattoni* as a parasite of the copepods *Pleuromamma gracilis* (Claus) from one station in the Indian Ocean, about half-way between south India and Madagascar, and of *P. borealis* (F. Dahl) from two stations in the South Atlantic, off South Africa. The material was obtained by the Valdivia Expedition, from depths of 2000–2500 m. Young and older stages of the parasite are described and figured. The adult stage differs from the specimens of *Ellobiopsis chattoni* described by Caullery (1910) in being smaller (422μ against 700μ), and in having a different shape. In Caullery's specimens the gonomere is much larger than the trophomere, in Steuer's figure the globular gonomere is much smaller than the pear-shaped trophomere. Moreover, the groove between the two parts of the parasite in Steuer's specimen is much more pronounced than in those of Caullery. Steuer classifies the Ellobiopsidae among the Flagellata.

Reichenow (1930). *Ellobiopsis chattoni* recorded as occurring in the North Sea and in the Baltic. Notes on the distribution of the other Ellobiopsidae.

Steuer (1932*a*). Description of *E. elongata*, a parasite of *Ctenocalanus vanus* Giesbr. from the Meteor Expedition (St. 57, about 50° S, 35° W, near South Georgia, from a depth of 50–100 m.). Differs from *Ellobiopsis chattoni* by its more slender, cylindrical trophomeres, which in full-grown specimens bear two globular gonomeres. The stalk penetrates into the appendage of the host.

Steuer (1932*b*). More elaborate notes on the specimens of *E. chattoni* dealt with in a previous paper (Steuer, 1928), with three more records of the parasite in the Indian Ocean (stations of the Valdivia Expedition) and one more record in the Atlantic, off South Africa (station of the Meteor Expedition). A map shows the distribution of *E. chattoni*, based on the data in Steuer's paper and in those from the previous literature.

Steuer (1933). A summary of the 1932*b* paper by the same author.

Marshall, Nicholls and Orr (1934). Note on the occurrence of *E. chattoni* on *Calanus finmarchicus* in Loch Striven (Firth of Clyde area).

Fage (1936). New generic name *Amallocystis* for *Staphylocystis*, preoccupied. Description of *Amallocystis fasciatus*, a parasite on the ventral side of the first abdominal segment of *Gnathophausia zoea* Will. S. (Mysidacea) from the Dana Expedition (off the Fiji Islands and off New Zealand, 3000 and 2500 m. wire respectively). Fage describes the characters separating the species from *Amallocystis racemosus* (Coutière), gives an account of the organ of fixation, and notes on cytology, and refers to the influence of the parasite on the host. One of the hosts, a male, does not appear to have undergone any change as a result of being infested by the parasite. On the contrary the other host, a female, shows a pronounced retardation in the development of the sexual characters. The oostegites of the parasitized female are considerably smaller than those of uninfested females of the same size, and the mass of hairs found on the sternal plates of normal females has remained very much under-developed in the specimen bearing the parasite.

Jepps (1937). Notes on young and adult stages of *Ellobiopsis chattoni* attached to the mouthparts and the second antenna of *Calanus helgolandicus* Claus from the Clyde Sea area, and on very young stages of the parasite attached to the setae of the appendages. The larger specimens showed well-developed roots penetrating into the appendages of the copepod. In some of the gonomeres the formation of buds leading to sporulation was observed. A plug and an anterior cone are described as often occurring on the top of the gonomere; these might be the remnants of a previous gonomere, detached from the trophomere before the present gonomere developed.

Fage (1938). Description of *Amallocystis capillosus*, a parasite of *Pasiphaea tarda* Kröyer from the Skagerrak. The external parts of the parasite form two tufts of long-stalked trophomeres, each tuft on one side of the base of the rostrum. The basal part of each tuft passes through a hole in the cuticle into the internal part of the parasite, forming the organ of fixation, which extends transversely under the rostrum of the host. This internal part has a rough surface. Fage remarks that the simple Ellobiopsidae, which may be found in various parts of their hosts, in all probability attain their full development on the spot where the spore originally attached itself. For the compound Ellobiopsidae, each species of which occurs in a definitely localized part of its host, it is hardly possible to believe that they originally fixed themselves on the spot. In connexion with this Fage points to the probability that in the life history of these parasites there occurs an internal stage.

Coutière (1938, 1940*a*, *b*). Reprinted previous papers by the same author (Coutière, 1911*a*–*c*).

Fage (1941). Data from a previous paper (Fage, 1936) with additional notes. *Amallocystis fasciatus* on a third specimen of *Gnathophausia zoea* (from off Guyana), and on two specimens of *G. ingens* (Dohrn), one from the Indian Ocean, the other from the Atlantic.

Fage (1942). Notes on the effect of the parasite *Amallocystis fasciatus* on its hosts.

Einarsson (1945). Remarks on *Amallocystis* sp., a parasite of the Euphausiids *Thysanoessa inermis* (Kröyer) and *Th. raschii* (M. Sars) from Icelandic waters. The parasite occurs on the carapace of the host, as a rule in the region of the genital gland, and in some cases in the region of the stomach. Often more than one parasite on one host. Description of the root system extending from the organ of fixation into the ovary of the host. The parasite seems to castrate the animals which it infests, as external sexual characters are totally absent and the ovary is completely disorganized in the specimens bearing the parasites.

Boschma (1948). Description of *Amallocystis fagei*, a parasite of *Euphausia vallentini* Stebbing and other Euphausiids not mentioned by name (material from various Discovery Stations in the Antarctic), with an account of the sieve plate occurring in the organ of fixation.

Amallocystis fagei Boschma

Staphylocystis racemosus Macdonald, 1927, p. 780.
Amallocystis sp. Einarsson, 1945, p. 158.
Amallocystis fagei Boschma, 1948, p. 448.

MATERIAL:

St. 665 (51° 41′ 30″ S, 29° 58′ 45″ W), 17. iv. 1931, net TYFB, depth of net 250–0 m., 1 ex. on *Euphausia frigida* H. J. Hansen. Transverse sections of host, Delafield's haematoxylin (Fig. 3*b*).

St. WS 770 (46° 03′ S, 66° 34′ W), 21. x. 1931, net N 100 B, depth of net 57–0 m., 6 ex. on *Euphausia vallentini* Stebbing. Three specimens figured in Pl. XXXVIII, figs. 1–5, 10; one specimen transverse sections of host, Ehrlich's haematoxylin (Pl. XXXIX); one specimen longitudinal sections of host, Delafield's haematoxylin (Pl. XL).

St. 712 (28° 02′ 06″ S, 43° 09′ 30″ W), 28. x. 1931, net TYFB, depth of net 224–0 m., 1 ex. on *Euphausia recurva* H. J. Hansen (Pl. XXXVIII, fig. 6).

St. 733 (62° 56′ 42″ S, 75° 02′ W), 21. xi. 1931, net N 100 B, depth of net 84–0 m., 1 ex. on *Euphausia frigida* H. J. Hansen.

St. 748 (55° 29′ 24″ S, 54° 13′ 48″ W), 29. xi. 1931, net N 100 B, depth of net 180–0 m., 1 ex. on *Euphausia frigida* H. J. Hansen.

St. 751 (51° 28′ 42″ S, 49° 17′ 42″ W), 1. xii. 1931, net N 100 B, depth of net 104–0 m., 2 ex. on *Euphausia frigida* H. J. Hansen. One specimen figured in Pl. XXXVIII, figs. 8 and 11; one specimen longitudinal sections of host, Ehrlich's haematoxylin (Fig. 4).

St. 766 (58° 51′ S, 36° 54′ W), 10. xii. 1931, net N 100 B, depth of net 102–0 m., 1 ex. on *Euphausia frigida* H. J. Hansen. Transverse sections of host, Delafield's haematoxylin (Fig. 3*a*).

St. 869 (43° 56′ 30″ S, 103° 24′ 18″ E), 5. v. 1932, net N 100 B, depth of net 68–0 m., 1 ex. on *Euphausia lucens* H. J. Hansen.

St. 871 (39° 32′ 06″ S, 107° 06′ 24″ E), 7. v. 1932, net N 100 B, depth of net 240–100 m., 1 ex. on *Thysanoessa gregaria* G. O. Sars. Transverse sections of host, Ehrlich's haematoxylin (Fig. 5).

St. 872 (37° 09′ 06″ S, 108° 47′ 12″ E), 7. v. 1932, net N 100 B, depth of net 128–0 m., 1 ex. on *Euphausia hemigibba* H. J. Hansen (Pl. XXXVIII, fig. 9).

St. 892 (52° 48′ 30″ S, 137° 00′ 24″ E), 31. v. 1932, net N 100 B, depth of net 93–0 m., 1 ex. on *Euphausia vallentini* Stebbing. Transverse sections of host, borax carmine (Fig. 2).

St. 963 (52° 01′ S, 139° 13′ 12″ W), 14. ix. 1932, net N 100 B, depth of net 320–128 m., 1 ex. on *Euphausia vallentini* Stebbing. Type specimen, transverse sections of host, Delafield's haematoxylin (Figs. 1, 9*b*).

St. 965 (47° 16′ 54″ S, 132° 25′ 06″ W), 16. ix. 1932, net N 100 B, depth of net 310–132 m., 1 ex. on *Thysanoessa gregaria* G. O. Sars (Pl. XXXVIII, fig. 7).

St. 1056 (50° 18′ S, 37° 04′ 30″ W), 4. xii. 1932, net N 100 B, depth of net 100–0 m., 1 ex. on *Euphausia vallentini* Stebbing.

The first record of this parasite undoubtedly is the specimen on *Meganyctiphanes norvegica* (M. Sars) identified by Macdonald (1927) as *Staphylocystis racemosus* (Coutière). As the author states that the parasite occurred on the carapace of this host, and as the host belongs to the Euphausiacea, it cannot have been the species of Coutière which lives on the underside of the abdomen of a host belonging to the Caridea.

More particulars on the parasite of the Euphausiids are given by Einarsson (1945). This author states that the parasite is closely allied to *Amallocystis racemosus* (Coutière), *A. fasciatus* Fage and *A. capillosus* Fage, and remarks that most probably it is a species new to science, which he provisionally indicates as *Amallocystis* sp. Einarsson states that this parasite, which he found on *Thysanoessa inermis* and *Th. raschii*, is always attached to the dorsal side of the carapace, usually in the middle or behind the middle, but in rare cases in the region of the stomach. Interesting is the following remark (Einarsson, 1945, p. 158): 'Usually there are more than one bundle of trophomeres and gonomeres present, most often three or more, which seem to have no connection with each other.' This points to the fact that in the North Atlantic, specimens of *Thysanoessa* may be infested by a number of separate individuals of the parasite.

Einarsson's fig. 81 distinctly shows that his parasite corresponds with those dealt with in the present paper. His figures of transverse sections of a specimen of *Thysanoessa* with *Amallocystis* sp. (loc. cit., fig. 83*b*, *c*) show the organ of fixation in its most strongly developed region, and the ramifications of the

parasite inside the ovary (referred to in the present paper as 'protoplasmatic excrescences' or 'root system'). Einarsson describes the chief particulars of the internal part of the parasite: 'The stalk of the parasite, which penetrates the carapace, may be followed in the sections, often dividing into branches which run horizontally through the internal organs, but sometimes it is confined to one strong continuation of the stalk' (loc. cit., p. 158). In the infested specimens of *Thysanoessa* Einarsson found that the external sexual characters are totally absent; it therefore seemed probable that the parasite castrates its host. Examination of sections of the ovary of a mature female and of an infested specimen showed that in the latter the ovary was completely disorganized.

Recently I published a short paper on the organs of absorption in a species of *Amallocystis* (Boschma, 1948), a preliminary communication dealing with a part of the material from the Discovery collections. The parasites of the Euphausiids were mentioned here as *A. fagei*; provisionally the peculiar manner of attachment to the region of the genital gland of the host was considered as a sufficient indication of its specific distinction. In this paper I mentioned protoplasmatic excrescences penetrating from the organ of fixation into the ovary (at the time I did not know that Einarsson already had described these prolongations of the organ of fixation), and showed that the cuticle of the organ of fixation possesses a distinct sieve plate through which the protoplasmatic excrescences protrude. Fage (1936) already had given as his opinion that the organ of fixation of *Amallocystis* not only serves as a means of attachment of the parasite, but that it also functions as an organ of absorption of food. After having found the sieve plate and the protoplasmatic excrescences emerging through this plate into the ovary I concluded that these are the real organs for the absorption of food; the cuticle of the organ of fixation itself is too thick to allow the passage of food.

A more detailed description of the Discovery material follows here.

The parasites are found slightly behind the middle of the dorsal surface of the carapace of the host. Their external part consists of a bundle of cylindrical bodies which are divided into a series of elements by distinct transverse grooves. On the larger specimens of the Euphausiids the parasites may show a considerable number of these cylindrical bodies; in one specimen on *Euphausia vallentini* (Pl. XXXVIII, figs. 1, 4) fifty of them could be counted. As a rule, however, this number in the parasites on *E. vallentini* does not exceed thirty (as in the specimen in Pl. XXXVIII, figs. 2, 5). The parasites of *E. frigida* have approximately the same number of cylindrical bodies (Pl. XXXVIII, fig. 8). On the parasites of *E. recurva* (Pl. XXXVIII, fig. 6), *E. lucens*, *E. hemigibba* (Pl. XXXVIII, fig. 9), and *Thysanoessa gregaria* (Pl. XXXVIII, fig. 7) ten to fifteen of these cylindrical bodies were counted.

The cylindrical bodies vary in length from 0·5 to 2·5 mm., and their transverse diameter is from 0·13 to 0·33 mm. They consist of up to eight elements, the proximal of which, the trophomere, is more or less conical, whilst the others, the gonomeres, have a more or less globular shape. The distal gonomere may grow out into a more elongated body (some of these are visible in Pl. XXXVIII, figs. 1, 4), which may easily break off from the top. The following gonomere then may show a distinct scar (visible in some of the gonomeres of Pl. XXXVIII, figs. 2, 10). Probably, however, this is not the natural manner of detachment of the ripe gonomeres. Numerous distal gonomeres show at their free extremities a kind of filament (distinctly visible in Pl. XXXVIII, figs. 8, 11), which consists of the shrivelled cuticle of the preceding gonomere from which apparently the spores have been set free.

As a rule the parasites of large specimens of the host are pronouncedly larger than those infesting smaller specimens of the host. Measurements of the transverse diameter of the gonomeres of various specimens yielded the following results. Two specimens on *Euphausia vallentini*, gonomeres 0·28–0·33 mm.; one specimen on *E. frigida*, gonomeres 0·28–0·33 mm.; another specimen on *E. frigida*, gonomeres 0·16–0·23 mm.; specimens on *E. hemigibba* and on *E. recurva*, gonomeres 0·13–0·16 mm.; specimen on *Thysanoessa gregaria*, gonomeres 0·13–0·16 mm.

The internal parts of the parasites were studied in sections. Six hosts with parasites were sectioned transversely and two longitudinally. In one of the latter the host proved to be infested by two parasites. The chief particulars of the various series of sections are given below.

(1) The type specimen, on *Euphausia vallentini* from St. 963 (Fig. 1). The section shows the external part of the organ of fixation from which a number of trophomeres are branching off, and the internal

Fig. 1. *Amallocystis fagei* Boschma on *Euphausia vallentini* Stebbing from St. 963 (type specimen). Transverse section of host. After Boschma (1948, fig. 2). *ch*, chitin; *e f*, external part of organ of fixation; *f*, organ of fixation; *h*, hepatopancreas of host; *i*, intestine of host; *m*, musculature of host; *o*, ovary of host; *p*, protoplasmatic excrescences; *s*, sieve plate; *t*, trophomere. × 160.

part of the organ of fixation embedded in the ovary of the host. The organ of fixation has a rather solid cuticle which in many parts shows folds or wrinkles. At the lower surface of the organ of fixation there is a region in which the cuticle is pierced by numerous holes, the sieve plate. Through the latter a number of protoplasmatic excrescences are seen to protrude into the ovary. These excrescences form the proximal part of the root system; the more distal part of the latter is not distinctly visible in the sections of this specimen. At the sides of the parasite there are a few irregular layers of chitinous matter of a pronouncedly yellow colour. Probably these were formed by the host as a reaction against

the parasite. In the sections the ovary does not appear to be degenerated, though the eggs have remained comparatively small.

A section of the lower part of the organ of fixation of the same specimen is shown in Fig. 9*b* (p. 299). The cuticle of the organ of fixation in many parts is rather strongly wrinkled. The sieve plate is more or less convex, and contains a great number of openings. Irregular protoplasmatic excrescences are protruding through the sieve plate; in some parts these excrescences themselves are covered with a cuticle.

(2) Specimen on *E. vallentini* from St. WS 770 (Pl. XXXIX). The section gives a distinct view of the various parts of the parasite. The organ of fixation is more or less panduriform, as its ovoid internal part is connected by a rather narrow neck to the again broadening external part. From the latter the basal parts of a number of trophomeres take their origin. The section shows several groups of gonomeres

Fig. 2. *Amallocystis fagei* Boschma on *Euphausia vallentini* Stebbing from St. 892. Transverse sections of host, *a* from a more anterior region than *b*. Letters as in Fig. 1. ×80.

spreading in all directions. At the underside of the organ of fixation the sieve plate is visible; through this plate some protoplasmatic excrescences often of considerable length are seen to protrude into the ovary of the host. In this specimen again the ovary shows no obvious signs of degeneration. The developing eggs seem to be of normal appearance.

(3) Specimen on *E. vallentini* from St. 892 (Fig. 2). The chief details of two sections, separated by a distance of 40μ, are given in the figure. One section (*b*) shows the rather narrow neck connecting the internal and the external parts of the organ of fixation. The external part at its top divides into trophomeres which extend in various directions. The lower part of the organ of fixation shows a large sieve plate through which protoplasmatic excrescences are seen to protrude into the ovary of the host. At its sides the internal part of the organ of fixation is surrounded by masses of chitin. The other section (*a*) is from a slightly more anterior part of the host. Here the sieve plate is still visible, on one side of the parasite.

(4) Specimen on *E. frigida* from St. 766 (Fig. 3*a*). Here again there is a distinct constriction between the external and the internal parts of the organ of fixation. The cuticle of the internal part is rather strongly wrinkled, and the sieve plate is found on one side of the parasite. Sections of two trophomeres and of one gonomere are to be seen.

(5) Specimen on *E. frigida* from St. 665 (Fig. 3*b*). In this specimen the organ of fixation does not show a constriction between the external and the internal parts. The sieve plate is present on one side of the parasite. As in the preceding specimen the organ of fixation is largely surrounded by chitinous matter.

(6) Specimens on *E. vallentini* from St. WS 770 (Pl. XL). Here the Euphausiid is infested by two specimens of the parasite of approximately the same size and shape. One (the right of the upper figure of Pl. III) is embedded in the ovary of the host slightly before the other. The parasites show a distinct neck-like constriction between their external and internal parts. The figure shows the sieve plate of the hindmost of the two parasites, and the protoplasmatic excrescences protruding through this plate. In the upper part of the figure sections of a number of trophomeres and gonomeres are visible.

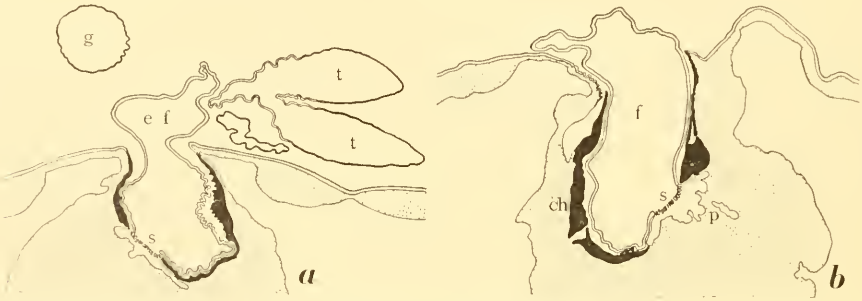

Fig. 3. *Amallocystis fagei* Boschma on *Euphausia frigida* H. J. Hansen. Transverse sections of hosts. *a*, specimen from St. 766; *b*, specimen from St. 665. Letters as in Fig. 1. In addition: *g*, gonomere. ×70.

A more enlarged photograph of part of a section next to the one of the upper figure is given in the lower figure of Pl. XL. It shows the lower part of the organ of fixation with the sieve plate and the protoplasmatic excrescences protruding through this plate. The figure shows further that the cuticle of the organ of fixation is rather thick, and that in some parts, especially in the right side of the figure, it is strongly wrinkled. On the proximal parts of the protoplasmatic excrescences also a cuticle has developed, though it is much thinner than that of the organ of fixation.

(7) Specimen on *E. frigida* from St. 751 (Fig. 4). The host was sectioned longitudinally. One of the sections (*a*) shows a median section of the parasite. Its organ of fixation does not present a pronounced constriction between the internal and external parts. The external part broadens into the common basal part of the trophomeres. The sieve plate is found in the lower part of the organ of fixation, pointing to the posterior region of the host. Through this plate protoplasmatic excrescences are seen to extend into the ovary of the host, where they divide into a well-developed root system. In this specimen the root system is pronouncedly different from other spaces in the ovary, so that the exact number of roots occurring in the sections could be drawn. At its sides the parasite is surrounded by irregular masses of chitin.

The other drawing (*b*) is after a section not far from the first one. It shows that the roots penetrate for a rather long distance towards the posterior region of the ovary of the host.

(8) Specimen on *Thysanoessa gregaria* from St. 871 (Fig. 5). Five sections are drawn, each section being at a distance of 20μ from the next. In the section of the most anterior part of the host (*a*) the cuticle of the organ of fixation is represented; on its inner wall it shows small excrescences which prove that this part represents the sieve plate. The next figure (*b*) shows the organ of fixation, a protoplasmatic excrescence, and some chitinous matter enveloping the organ of fixation. The next figure (*c*) does not

show any important changes. In the following figure (*d*) the organ of fixation is divided into a larger part which is largely external, and a smaller part in the lower region of the ovary of the host. In the last figure (*e*) this smaller part is still visible. It forms a distinct prolongation of the organ of fixation, penetrating the ovary of the host in a posterior direction. Moreover, the figures show sections of trophomeres and gonomeres above the dorsal surface of the host.

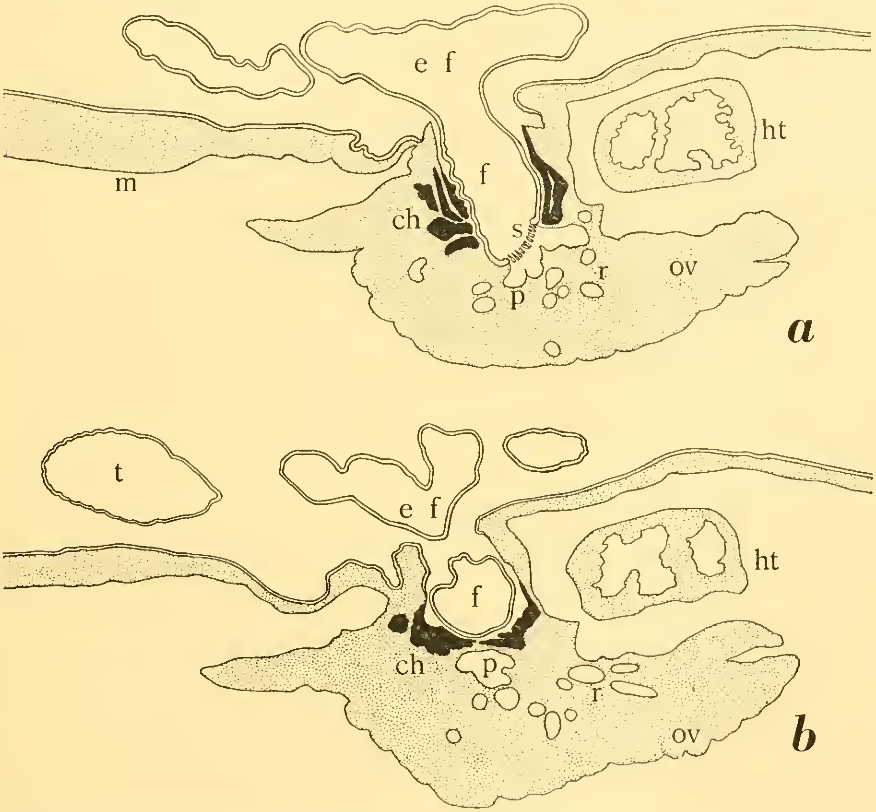

Fig. 4. *Amallocystis fagei* Boschma on *Euphausia frigida* H. J. Hansen from St. 751. Longitudinal sections of host; *a*, approximately in the median plane; *b*, slightly to one side. Letters as in Fig. 1. In addition: *ht*, heart of host; *ov*, ovary of host; *r*, roots. × 107.

It is interesting that the specimen on *Th. gregaria* is the only one in which the organ of fixation possesses a prolongation of the kind described here. In the other specimens examined the organ of fixation terminates in a blunt, somewhat broadened extremity.

Externally the parasites of the various species of Euphausiids are very much alike. The larger specimens may show a much larger number of trophomeres and gonomeres than the smaller specimens, and in the latter the size of the trophomeres and gonomeres may be smaller than in the former, but these differences do not point to a specific distinction. Moreover, internally the examined specimens are almost entirely similar. As the organ of fixation of the specimen on *Th. gregaria* possesses a distinct spur directed posteriorly, causing a slightly different aspect of this organ as compared to

that of the other specimens, this might point to a distinction. For the present, however, this difference seems to be of too little importance for a specific character, so that I am including the specimens on *Thysanoessa* in the species *Amallocystis fagei*.

On account of lack of sufficient material for comparison, and owing to deficient knowledge of the structure of the Euphausiacea, no attempt was made to determine the influence of the parasites on the sexual characters of the hosts. It may be observed here that all the parasitized specimens of which

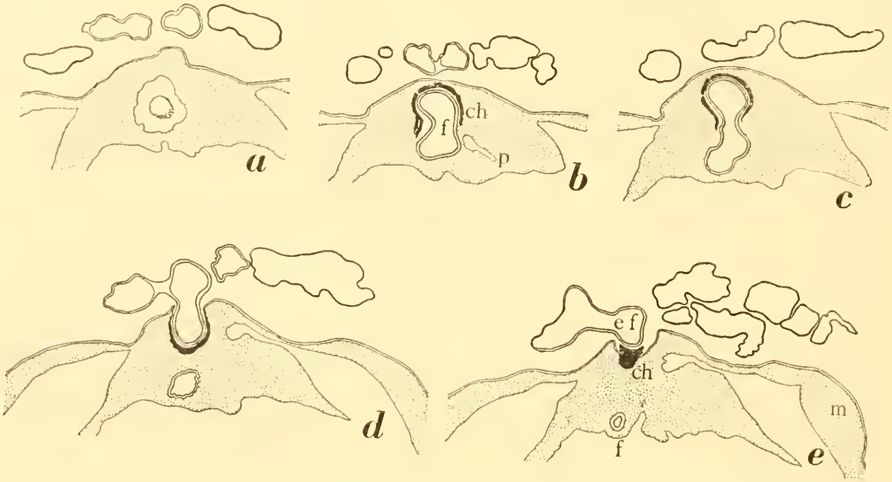

Fig. 5. *Amallocystis fagei* Boschma on *Thysanoessa gregaria* G. O. Sars from St. 871. Transverse sections of host. Letters as in Fig. 1. ×80.

sections were made are of the female sex. As already remarked above, the ovary of these infested specimens does not give the impression of being rudimentary or decidedly under-developed. It is quite possible, and it is even to be expected, that in normal specimens of the same size the ovary is much more fully developed. In Einarsson's infested specimens of *Thysanoessa inermis* and *Th. raschii* the ovary appeared to be completely disorganized, and these specimens did not show secondary sexual characters (cf. Einarsson, 1945). The differences in the state of development of the ovary in the specimens from the Antarctic as compared to Einarsson's specimens from the region of Iceland may be due to the fact that in the latter as a rule more than one parasite was found on each infested specimen, whilst in the former the parasite very rarely occurs in more than one specimen on one host.

Amallocystis umbellatus n.sp.

MATERIAL:

St. 81 (32° 45′ S, 8° 47′ W), 18. iv. 1926, net 450 H, depth of net 650–0 m., 1 ex. on *Hoplophorus novae-zeelandiae* De Man (Fig. 11).

St. 692 (02° 02′ 15″ N, 30° 08′ W), 9. v. 1931, net TYFB, depth of net 350–0 m., 1 ex. on *H. grimaldii* Coutière. Type specimen (Pl. XLI, figs. 1, 2, and Figs. 6–9*a*, 10). Transverse sections of part of host containing parasite, Delafield's haematoxylin.

SPECIFIC CHARACTERS. External part consisting of numerous tufts of trophomeres and gonomeres, united with long stalks to the organ of fixation. Parasites of species of *Hoplophorus*, attached to the ventral surface of the first or second abdominal segment.

Of the two specimens the larger (the type specimen) was studied in sections, and of the other some particulars of its external part are mentioned below.

A. THE SPECIMEN ON *HOPLOPHORUS GRIMALDII* COUTIÈRE

The parasite (Pl. XLI, fig. 1) is attached to the ventral surface of the first abdominal segment of its host. Its external part consists of a large number of trophomeres with gonomeres which are arranged in separate tufts each provided with a stalk of considerable length. The tufts as a rule are composed of ten to twenty trophomeres (Fig. 6); in Pl. XLI, fig. 2, a side view of the whole mass of the external part, about fifteen of the tufts are visible. Assuming that approximately one-fifth of the total mass of tufts is visible in the figure the full amount of trophomeres in this specimen is estimated at 750–1500. The whole mass of trophomeres and gonomeres as shown in the figures in Pl. XLI has a greater diameter of 8 mm. and a height of 5 mm. The trophomeres have a conical shape, and they gradually broaden towards their distal extremity, where they bear two or three (as a rule three) gonomeres. The latter have a globular shape with the exception of the most distal gonomere, which as a rule is more or less elongated. The thickness of the gonomeres varies from 165 to 225 μ; the trophomeres are slightly thinner.

The arrangement of the trophomeres in tufts which are separately connected with long stalks to the organ of fixation gives the parasite a superficial resemblance to a compound umbel. This peculiarity is expressed in the trivial name *umbellatus*.

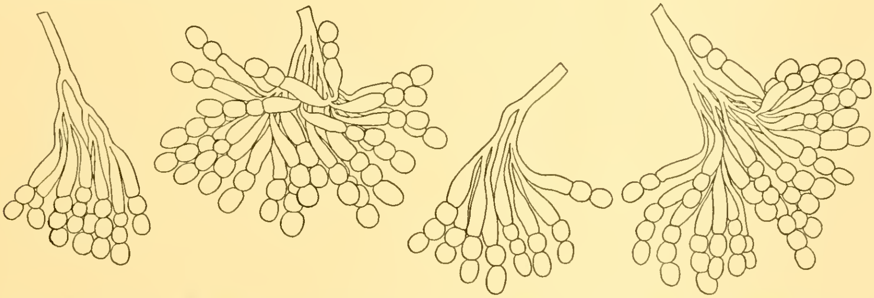

Fig. 6. *Amallocystis umbellatus* n.sp., type specimen. Tufts of stalks with trophomeres and gonomeres. × 15.

One section of the parasite with its external mass of tufts of trophomeres and gonomeres is represented in Fig. 7. In the region of this section the external part as well as the internal part of the organ of fixation are visible, the two parts being connected by a rather narrow neck. The internal part of the organ of fixation is surrounded by a number of roots, some of which penetrate into the marginal parts of the ventral nerve cord, whilst also in the tissues of the host directly under the cuticle there are also numerous roots. Some of these roots are found at a considerable distance from the organ of fixation, as, for instance, the one in the body musculature at the upper part of the left side of the figure.

The figure, moreover, shows sections of seven or eight tufts of trophomeres and gonomeres. Of some of these the stalks only are to be seen, of others stalks and trophomeres, and of others again trophomeres and gonomeres.

More details of the organ of fixation and of the root system are shown in Fig. 8. Here the stalks with their trophomeres and gonomeres are not represented in the figures. The parts belonging to the host are stippled, the organ of fixation with its rather strong cuticle is drawn with a double line, and the roots are drawn with single rather thick lines. Fig. 8*a* is the most anterior of the sections represented here; each following drawing is of a section from a more posterior region. The distances between the sections figured are: *a–b*, 100 μ; *b–c*, 110 μ; *c–d*, 90 μ; *d–e*, 140 μ; *e–f*, 120 μ; *f–g*, 90 μ; *g–h*, 100 μ; *h–i*, 80 μ; *i–j*, 140 μ. The section drawn in Fig. 7 is exactly between those of Fig. 8 *g* and *h*.

In Fig. 8*a* the anterior part (anterior in so far as it points to the anterior region of the host) of the organ of fixation is found in the peripheral part of the ventral nerve cord of the host. It is indicated

by *f*, and drawn with a double line, showing the thickness of its wall. In the peripheral part of the ventral nerve cord there are, moreover, four roots of the parasite. Six other roots are found in the body musculature of the host.

Fig. 8*b* does not differ in any important detail from Fig. 8*a*. The ventral nerve cord contains, besides the anterior part of the organ of fixation, four roots. Numerous roots are present in the body musculature of the host.

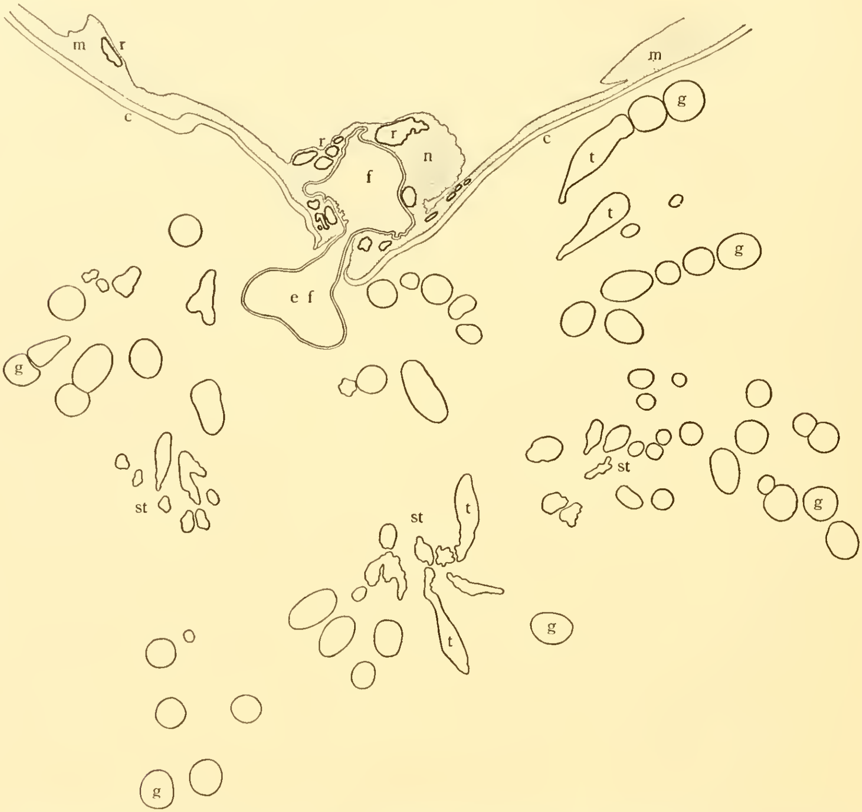

Fig. 7. Transverse section of the central part of the ventral region of the first abdominal segment of *Hoplophorus grimaldii* Coutière, with *Amallocystis umbellatus* n.sp., type specimen. Section from the region between those of Fig. 8 *g* and *h*. *c*, cuticle of host; *e f*, external part of organ of fixation; *f*, organ of fixation; *g*, gonomere; *m*, musculature of host; *n*, ventral nerve cord of host; *r*, root; *st*, stalks; *t*, trophomere. × 34.

In the section of Fig. 8*c* the organ of fixation is much wider. There are a few roots in the ventral nerve cord, some in or against the musculature under the cuticle, and some against another muscle (in the right side of the figure).

In Fig. 8*d* the ventral nerve cord is connected by a strand of tissue to the musculature covering the body wall. The parts of the parasite are not very different from those shown in Fig. 8*c*. One of the roots, in the peripheral region of the ventral nerve cord, is sectioned more or less longitudinally.

In the section shown in Fig. 8*e* the ventral nerve cord is connected to the body wall by a broad mass of tissue. The organ of fixation of the parasite here is already comparatively wide. There are a few roots of large size and a great number of smaller roots.

In Fig. 8*f* the organ of fixation forms a kind of neck protruding towards the body wall of the host. The ventral nerve cord is connected to the body of the host by means of a broad mass of tissue. Several large roots are visible here (one in the musculature at some distance from the median plane, at the left side of the figure), and numerous smaller roots.

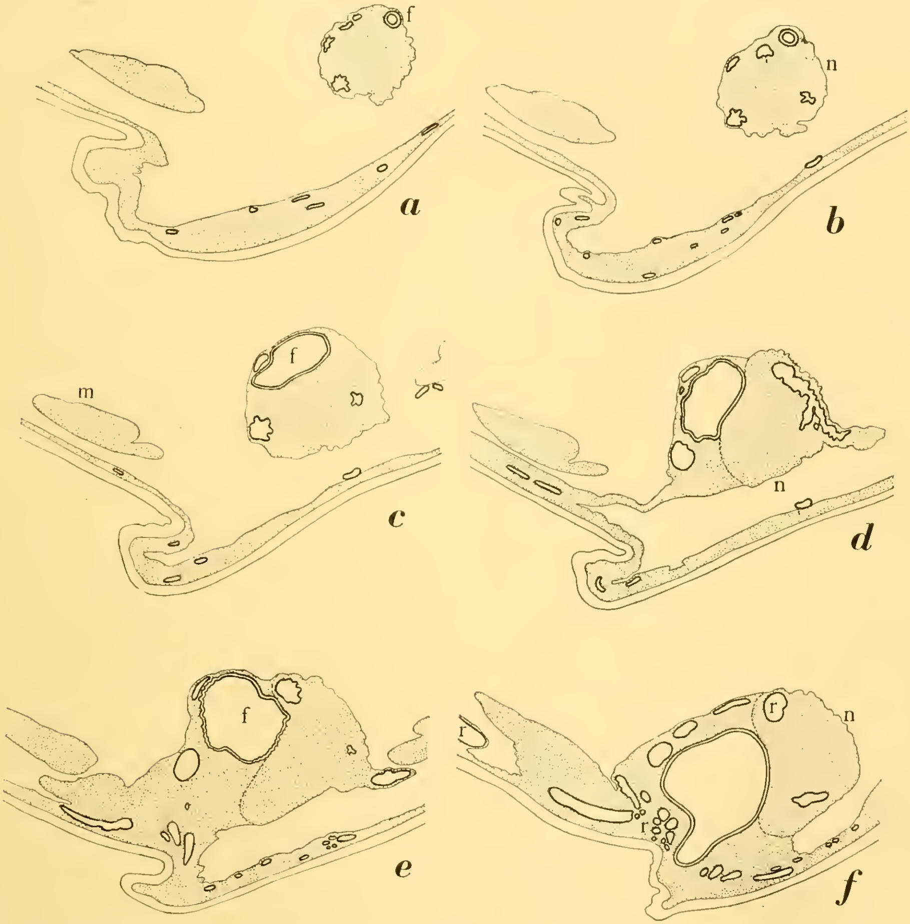

Fig. 8*a–f*. Transverse sections of the central part of the ventral region of the first abdominal segment of *Hoplophorus grimaldii* Coutière, with *Amallocystis umbellatus* n.sp., type specimen. *a* from a slightly more anterior region than *b*, each following section from a more posterior region. Stalks, trophomeres and gonomeres omitted. Letters as in Fig. 7. ×45.

Fig. 8*g* shows the organ of fixation in the region in which it attains its largest size. Its middle part is more or less constricted and forms a kind of neck uniting the internal part to the external part. Surrounding the internal part of the organ of fixation there are a great many large and smaller roots. One of these roots has a rather thick wall. It is the proximal part of one of the larger roots.

In Fig. 8*h* the external part of the organ of fixation is visible as a triangular mass next to the body wall of the host. The internal part of the organ of fixation and a great number of roots of various sizes are to be seen in the mass of tissue connecting the ventral nerve cord to the body wall, and in the

ventral nerve cord itself. A few of the roots which have just branched off from the organ of fixation have a rather strong wall, drawn with a double line in the figure. The internal part of the organ of fixation in this section shows the proximal parts of some large roots (in the upper and in the lower parts). Moreover, in the organ of fixation there is a series of cuticular formations which undoubtedly represent a sieve plate. In the section there is a series of small cuticular bars arranged in a crescentic row. Inside and outside this row there are a few more of these cuticular formations, so that the sieve plate is not as distinct as in *Amallocystis fagei*. More details of this sieve plate will be noted below.

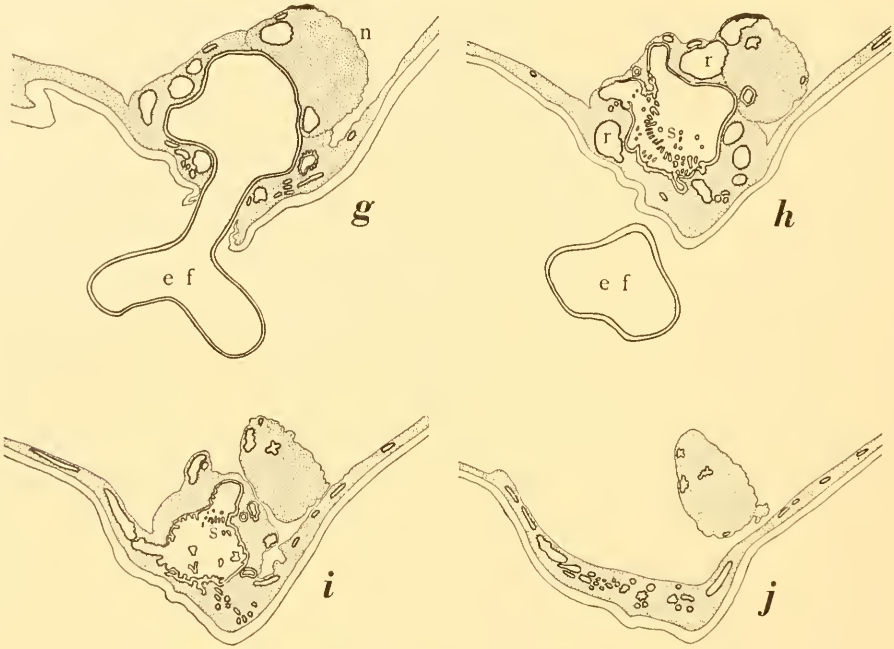

Fig. 8 *g–j*. For explanation see Fig. 8*a–f*. In addition: *s*, sieve plate. ×45.

In the section of Fig. 8*i* the ventral nerve cord is no longer connected with the mass of tissue enveloping the parasite. In the nerve cord itself there are still a few roots. The internal part of the organ of fixation shows one root penetrating into the musculature of the body wall (in the left half of the figure). Moreover, there is one large root in the upper part of the organ of fixation. This root is partially separated from the organ of fixation by a sufficiently distinct sieve plate. On the wall of the organ of fixation there are numerous more or less irregular cuticular excrescences, and in the interior of this organ there are a few irregular masses of cuticular matter, the whole forming a part of, or being connected with, the sieve plate of the section in Fig. 8*h*.

The last section represented here (Fig. 8*j*) shows parts of the root system, in the ventral nerve cord as well as in the musculature of the body wall. Especially in the latter there are a great number of roots.

The internal part of the organ of fixation, as it appears in the section preceding that in Fig. 8*h*, is drawn on a larger scale in Fig. 9*a*. The organ of fixation is covered with a comparatively thick cuticle, which is also present on the thick roots extending from the organ of fixation. In the lower part of the figure there are more or less irregular excrescences of the cuticle which protrude as a trabecular mass into the organ of fixation. This trabecular mass is arranged in a more or less crescentic manner,

partially dividing the left part of the organ of fixation from the larger right part. Now from this left part the large roots take their origin (cf. also Fig. 7*h*), and the whole configuration of this part of the organ of fixation presents a striking similarity to that found in *A. fagei* (cf. Fig. 9*b*).

In *A. fagei* the organ of fixation has a rather thick cuticle (necessary to ensure a solid fixation of the parasite in its host); part of this cuticle is pierced by a system of holes so that a sieve plate is formed through which protoplasmatic excrescences (the roots) can protrude. In *A. fagei* the proximal parts of these roots may also develop a cuticle, as in the specimen of Fig. 9*b*.

The external part of *A. fagei* does not show more than about fifty trophomeres, so that the parasite is securely fixed to its host by means of the simple globular or oval organ of fixation. In *A. umbellatus*, however, which may have 750–1500 trophomeres, this enormous mass of external organs necessitates the strengthening of the organ of fixation into an immovable organ of anchorage. Originally in the specimen of *A. umbellatus* described here the organ of fixation may have had a shape quite similar to

Fig. 9*a*. *Amallocystis umbellatus* n.sp., type specimen. Section preceding the one of Fig. 8*h*. Organ of fixation with sieve plate. *f*, organ of fixation; *r*, root. × 163.

Fig. 9*b*. *Amallocystis fagei* Boschma, type specimen. Section of lower part of organ of fixation. *f*, organ of fixation; *p*, protoplasmatic excrescences; *s*, sieve plate. × 283.

that found in *A. fagei*. It must have had a strong cuticle, but the part of the organ of fixation to the left of the sieve plate in Fig. 9*a* probably had a thin cuticle, so that the protoplasmatic excrescences (the roots) might absorb food from the host. Gradually the root system became more divided and more strongly developed; at the same time the number of external parts (trophomeres and gonomeres) increased, necessitating a stronger fixation of the parasite. The proximal parts of the root system now became covered with a thick and strong cuticle, thereby forming a part of the organ of fixation in securing a stronger hold of the parasite on its host. The sieve plate which was present between the organ of fixation and the roots now had lost its direct function, but it remained as it was, and the process of formation of a trabecular mass of cuticular excrescences even continued, so that now in some parts two rows of trabeculae are visible.

In the type specimen of *A. umbellatus* the sieve plate therefore appears to be an organ which has had its use as long as the parasite was comparatively young and possessed a few trophomeres only. It has lost its real function now, but it has remained where it originally developed. A comparison with the sieve plate of *A. fagei* shows that the trabecular mass in *A. umbellatus* must be regarded as being homologous with the former.

The internal part of the organ of fixation forms a more or less bulbous expansion which is protracted

into a long pointed spur extending in the anterior direction of the host. In this respect the organ of fixation of *A. umbellatus* corresponds exactly with that of *A. fasciatus*, in which Fage (1936) described a similar excrescence. Moreover, in *A. fasciatus* the organ of fixation has a number of shorter excrescences of varying shape pointing in a lateral or posterior direction (Fage, 1936, fig. ii*c*). In all probability the latter represent the proximal part of the root system, as they show a certain similarity to the corresponding parts of *A. umbellatus*, where the large proximal roots are confined to the region of the parasite turned towards the posterior part of the host.

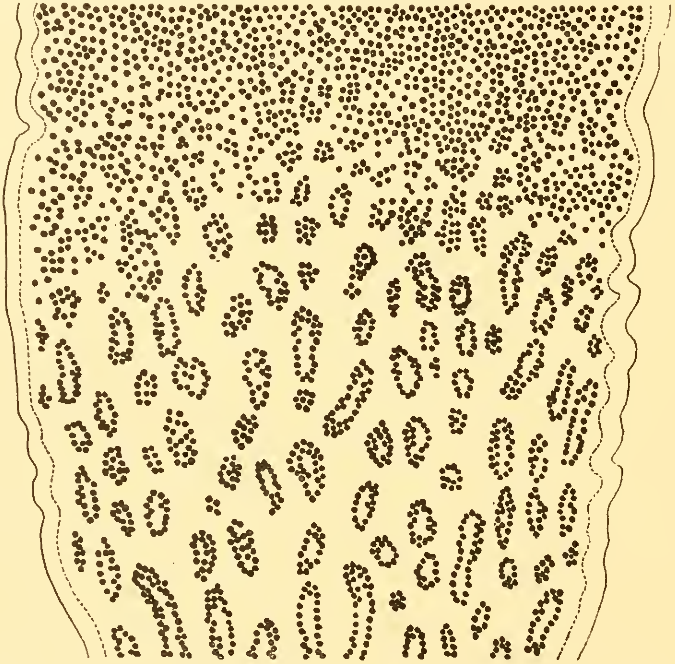

Fig. 10. *Amallocystis umbellatus* n.sp., type specimen. Part of a longitudinal section of a trophomere, showing the arrangement of the nuclei. ×825.

No studies were made of cytological details of the parasite. A few remarks on the trophomeres and the gonomeres may be given here. In the stained sections the trophomeres have a pink colour, the younger gonomeres may have the same colour or may have become a slightly darker red. The older gonomeres are stained much more deeply, and often show a dark blue colour. In the gonomeres the nuclei appear to be more or less evenly distributed throughout the whole organ. In the trophomeres, however, there is a distinct difference between the proximal part and the distal region. In the proximal part the nuclei are arranged in groups so as to form clusters that with their greater diameter are more or less parallel to the longitudinal axis of the trophomere. This occurs in about the whole of the proximal third part of the trophomere. In a more distal region the groups of nuclei become more indistinct, and finally the nuclei become more or less evenly distributed in the trophomere. The region of transition of the groups of nuclei into a rather uniformly scattered mass of nuclei is shown for one of the trophomeres in Fig. 10. It appears as if in the proximal region of the trophomeres the nuclei are found on more or less parallel strands of tissue, whilst they do not occur in the intervening spaces. The phenomenon referred to here is to be observed in all the trophomeres of the series of sections.

B. THE SPECIMEN ON *HOPLOPHORUS NOVAE-ZEELANDIAE* DE MAN

The specimen is attached to the ventral surface of the abdomen of its host, and the external part protrudes through the integument joining the first and second abdominal segments. The parasite was examined externally only, but the pleurae of the left first and second abdominal segments were removed to obtain a better view of the parasite. In the side view of the external parts of the parasite (Fig. 11*b*) the pleurae are represented to show the situation of the parasite in regard to its host. In the figure approximately 100 trophomeres with their gonomeres are visible. If we assume that about one-fifth of the whole number of trophomeres is visible here, the total number amounts to 500, a considerably smaller number than that of the type specimen. As in the latter the trophomeres are united in tufts that with usually long stalks originate from a common centre. The whole external mass in side view has a larger diameter of about 5 mm., and a height of about 2 mm.

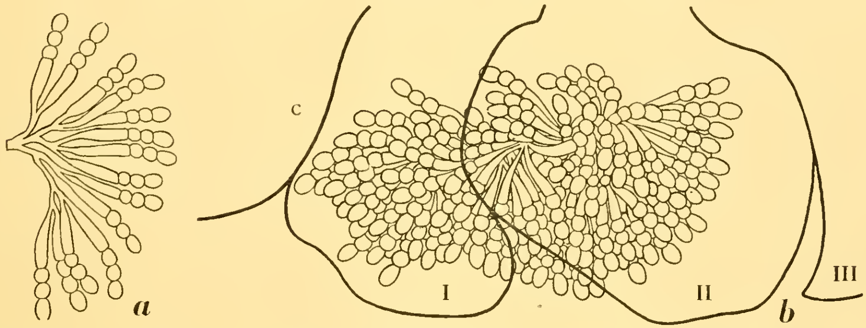

Fig. 11. *Amallocystis umbellatus* n.sp., specimen on *Hoplophorus novae-zeelandiae* De Man. *a*, tuft of stalks with trophomeres and gonomeres; *b*, external part of parasite *in situ* on host. *c*, carapace; I, first abdominal segment; II, second abdominal segment; III, third abdominal segment. × 15.

Fig. 11*a* represents a single tuft of trophomeres and gonomeres. As a rule each trophomere bears three gonomeres, which are of a globular shape except the distal gonomere which is usually slightly more elongated. The diameter of the gonomeres varies from 140 to 195μ. They are, therefore, slightly smaller than those of the specimen on *Hoplophorus grimaldii*, but in all other respects the external part of the two parasites is quite similar.

The host of the type of *Amallocystis umbellatus*, a specimen of *Hoplophorus grimaldii* Coutière, appears to be a female. The pleopods of the first and second abdominal segments seem to be of normal shape. Every trace of an appendix masculina as it occurs on the second pleopod of the male is absent. Moreover, the anterior angle of the first abdominal pleuron is evenly rounded, without any indication of an incision, so that this pleuron has the typical character of the female.[1]

The host of the other specimen of *Amallocystis umbellatus*, *Hoplophorus novae-zeelandiae* De Man, again has all the characters indicating the female sex. Here also the pleopods of the first and second abdominal segments show a normal development, whilst the appendix masculina is entirely absent. As in the former specimen there seem to be no indications of a deviation from the normal type as a result of the parasitization.

[1] Cf. Chace, Jr., F. A., 1940, Plankton of the Bermuda Oceanographic Expeditions. IX. The Bathypelagic Crustacea. *Zoologica*, vol. XXV, p. 188 (concerning *Hoplophorus grimaldii* Coutière): 'Although there is a well developed appendix masculina in the adult males of this species, there is also a sexual distinction involving the first abdominal pleuron as in the preceding species; in the male, the lower anterior angle of this pleuron is deeply incised so that the angle formed approaches a right angle, while in the female this angle, if present at all, is very obtuse.'

Amallocystis capillosus Fage

Amallocystis capillosus Fage, 1938, p. 287.

MATERIAL:

St. WS 748 (53° 41′ 30″ S, 70° 55′ 00″ W), 16. ix. 1931, net NR, depth of net 300 (0–?) m., 2 ex. on *Pasiphaea acutifrons* Bate (Pl. XLI, figs. 3, 4). One specimen, transverse sections of part of host containing parasite, Delafield's haematoxylin (Figs. 12–16).

The parasite is attached to the basal part of the rostrum of the host, where it forms a pronounced ridge on the carapace. The external part of one of the parasites is a mass of stalks with trophomeres and gonomeres with a larger diameter of about 4·6 mm. and a height of about 3·5 mm. (Pl. XLI, fig. 3); the corresponding dimensions of the external part of the other parasite (the sectioned specimen) are about 4 by 3·5 mm. (Pl. XLI, fig. 4). In the external masses of each of the two parasites about fifty to seventy trophomeres can be counted, though originally there must have been a considerably larger number, as in Fig. 15 already parts of eighty-three trophomeres are visible, the majority of these being sections of the stalks. Apparently a great number of trophomeres have become detached from their stalks after preservation of the parasites.

At each side of the carina which forms the proximal part of the rostrum of the host there is a bundle of slender stalks of various lengths, sometimes extending rather far in an anterior direction. At its extremity each stalk passes into a trophomere of an elongate shape, more or less cylindrical with a tapering proximal part. On the top of each trophomere there may occur one gonomere of elongatedly oval shape, which may have a length of about 0·6 mm., whilst the trophomere may be about twice as long. The transverse diameter of the trophomeres and the gonomeres is from 0·15 to 0·25 mm.

The internal part of the parasite was studied in transverse sections of the rostral region of the host. Drawings of three sections containing the internal part of the parasite are given here. The most anterior (Fig. 12) is at a distance of 60μ from the following (Fig. 13), the latter at a distance of 170μ from the next figured section (Fig. 14). Moreover, part of a section not containing internal parts of the parasite is drawn in Fig. 15. This section is at a distance of 330μ from the one drawn in Fig. 12.

The series of sections begins at the posterior region of the part of the host sectioned, so that the right side of the host is found at the left side of the figures.

In Fig. 12 at each side of the carina (the proximal part of the rostrum) there is a number of stalks, of trophomeres and gonomeres. Some of the stalks are drawn with a double line, as they have a rather thick cuticle; they belong to the proximal portions of the external part of the parasite. At the right side of the basal part of the carina (left in the figure) the latter is pierced by a hole through which the external part of the organ of fixation of the parasite protrudes. This external part here forms a short tube which at its top divides into a number of stalks. Between the carina and the antennal gland of the host (indicated by a broken line) there is an irregular mass of cuticular matter belonging to the parasite; this mass represents the proximal part of the root system. The figure further shows a number of roots extending into the tissues of the host (the roots indicated with a rather heavy line).

Fig. 13 shows again at each side of the carina a number of stalks, of trophomeres and of gonomeres of the parasite. The organ of fixation in the region of this section attains its largest size. It is a more or less irregularly globular organ, which in the figured section forms an excrescence penetrating through a hole at the left side of the basal region of the carina (right in the figure). This excrescence is of a similar shape to the one in Fig. 12; at its top it divides into a number of stalks. The organ of fixation itself is covered with a rather thick wall, which in its lower part shows a peculiar structure that must be considered to be homologous with the sieve plate as it occurs in *Amallocystis fagei*. Under this sieve plate there is a dense mass of cuticular matter with a great number of openings; it is a complicated

canal system with strong cuticular walls, or a mass of trabecular cuticular bars leaving openings between themselves. In the figures this mass is indicated as the proximal part of the root system. From this proximal part of the root system a large branch extends to the left (to the right in the figure), and

Fig. 12. Transverse section of the rostral region of *Pasiphaea acutifrons* Bate with *Amallocystis capillosus* Fage. *e f*, external part of organ of fixation; *g*, gonomere; *gl*, antennal gland of host; *pr*, proximal part of root system; *r*, roots; *rs*, rostrum of host; *st*, stalks. ×67.

at its end this branch divides into smaller roots which in the section of the figure show their cuticular walls only. Another branch of the proximal root system is to be seen directly under the main mass. This branch consists of cuticular matter with very small openings. A third branch of the proximal root system is visible in the lower part of the figure. In this branch the openings are large in comparison to the cuticular matter. The figure further shows some roots with thin walls (though drawn with rather heavy lines) in the vicinity of the antennal gland, at each side of the median plane.

Fig. 14 shows again at each side of the carina sections of a number of stalks, of trophomeres and of gonomeres. Here there is a second hole at the right side of the basal region of the carina (left in the figure). Through this hole an excrescence of the organ of fixation protrudes, thereby becoming external. At its top it divides into a number of stalks. One side of the internal part of the organ of

Fig. 13. Same specimen as Fig. 12, a slightly more posterior section. Letters as in Fig. 12. In addition: *f*, organ of fixation; *s*, sieve plate. ×67.

fixation shows the connexion with the proximal part of the root system, the complicated mass of cuticular matter with numerous openings of various sizes. A few roots with thin walls are to be seen in the tissues surrounding the organ of fixation.

In the sectioned specimen therefore the organ of fixation possesses one excrescence which at the left side of the host pierces the basal part of the rostral carina, and two excrescences which at some distance from each other independently traverse the cuticle at the right side of the basal part of the rostral carina.

The sections in Figs. 12–14 show a comparatively small quantity of stalks and trophomeres and gonomeres; in a more anterior region of the host this number is considerably larger, as in the section after which Fig. 15 was drawn. At the left side of this figure not all the external parts of the parasite have been represented. The shrunken appearance of some of the trophomeres or gonomeres in all probability is a result of the preservation of the material.

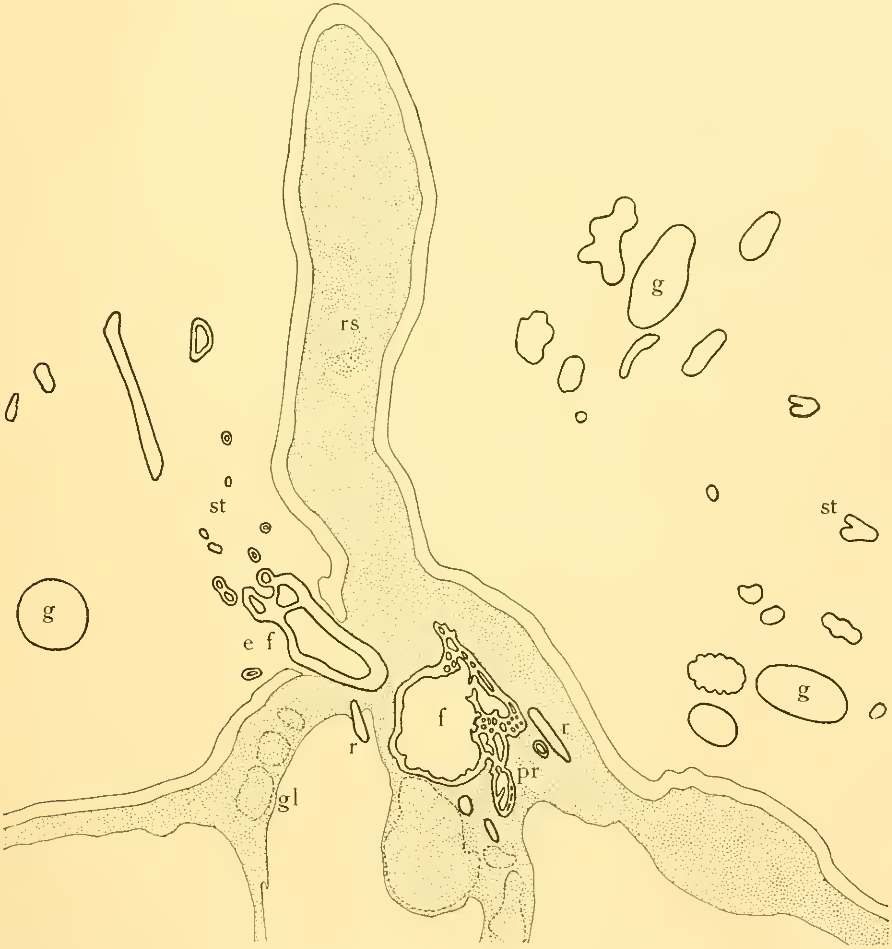

Fig. 14. Same specimen as Figs. 12 and 13, a slightly more posterior section than the one of Fig. 13. Letters as in Fig. 12. In addition: *f*, organ of fixation. ×67.

The sieve plate of the sectioned specimen is shown on a larger scale in Fig. 16. Here *a* is a part of the section shown in Fig. 13, and *b* is a part of a section between those of Figs. 13 and 14, at a distance of 30μ from the section of Fig. 14. Each of the two figures shows a distinct sieve plate, as distinct as that found in *A. fagei*, but behind this sieve plate there is very little open space, as the part of the parasite referred to here as the proximal part of the root system almost immediately joins here the organ of fixation. This proximal part of the root system is a cuticular mass with comparatively irregular

openings, or, more precisely, it is an intricate mass of trabecular cuticular matter which leaves but little space between the bars and lamellae composing this cuticular mass. In Fig. 16*b* the connexion of the internal part of the organ of fixation with the root system through the sieve plate is more apparent than in Fig. 16*a*.

Undoubtedly young specimens of *A. capillosus* possess a sieve plate through which protoplasmatic excrescences from the internal part of the organ of fixation penetrate into the tissues of the host.

Fig. 15. Same specimen as Figs. 12–14, transverse section of the rostral region slightly behind the base of the free rostrum. Letters as in Fig. 12. In addition: *t*, trophomere. ×67.

During further development the increasing volume of the external part of the parasite causes a need for a stronger fixation of the internal parts. As the functioning root system then has penetrated for a comparatively long distance into the organs of the host, the proximal part of the root system then can be added to the organ of fixation by the formation of additional cuticular matter. The sieve plate, which in young stages must have formed an important part of the parasite, during growth of the organism gradually must have lost its original function. Though in older stages it is no more of special use to the parasite, the sieve plate has remained where at first it was formed.

Fage (1938) describes the lower surface of the organ of fixation of *A. capillosus* as having a rough surface. In the figure (loc. cit., fig. 3) this is also indicated. Undoubtedly the specimens examined by Fage had the same structure of the internal parts as the specimen described above. The rough

surface of the organ of fixation in Fage's specimens in reality was the proximal part of the root system with its intricate trabecular mass of cuticular matter, bringing about a pronouncedly uneven surface of this part of the parasite.

The six specimens of *Pasiphaea tarda* Kröyer from the Skagerrak infested with *Amallocystis capillosus* Fage were all of the male sex. Curiously enough the two specimens of *Pasiphaea acutifrons* Bate from the Strait of Magellan bearing the same parasite are both females. They do not show any indication of differences from normal females, as might be expected as a result of the parasitization. As, however, no material of uninfested specimens of this rare species was available, it is not altogether certain that in every respect they are of normal appearance.

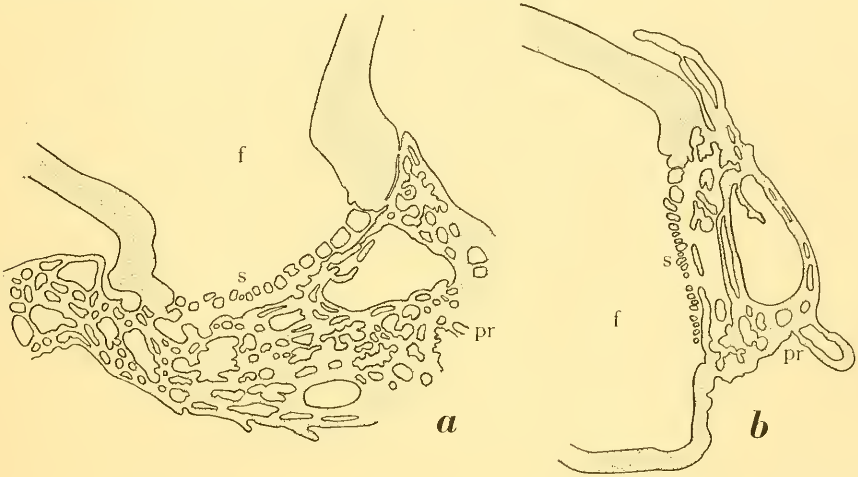

Fig. 16. *Amallocystis capillosus* Fage, specimen of Figs. 12–15. *a*, detail of fig. 13, further enlarged; *b*, sieve plate of section between those of Figs. 13 and 14. *f*, organ of fixation; *pr*, proximal root system; *s*, sieve plate. × 190.

THE CHARACTERS OF THE SPECIES OF THE GENUS *AMALLOCYSTIS*

A synopsis of the characters of the described forms of the genus *Amallocystis*, based on data from the literature and on those of the present paper, shows the following particulars.

(1) The parasite mentioned and figured by Bate (1888)

Host and manner of attachment: *Pasiphaea cristata* Bate, ventral surface of second abdominal segment.

Number and arrangement of trophomeres: Approximately fifty (?), in a bundle spreading from a common centre.

Shape of trophomeres and gonomeres: Trophomeres elongately cylindrical or conical, twice or $2\frac{1}{2}$ times as long as broad; gonomeres globular to oval.

Number of gonomeres on each trophomere: Three.

Dimension of gonomeres: Unknown.

Organ of fixation: Unknown.

(2) *Amallocystis racemosus* (Coutière)

Host and manner of attachment: *Pasiphaea tarda* Kröyer, ventral surface of third abdominal segment.

Number and arrangement of trophomeres: About fifty, in a single bundle attached to a common basal organ of fixation. Total length of the trophomeres with their gonomeres up to 4 mm.

Shape of trophomeres and gonomeres: Trophomeres elongately cylindrical, gonomeres oval, to about twice as long as broad.

Number of gonomeres on each trophomere. Up to seven.

Dimensions of gonomeres: Transverse diameter on an average $\frac{1}{2}$ mm. (Coutière, 1911*c*, text), 0·18–0·3 mm. (Coutière, 1911*c*, text-fig. i), 0·3–0·4 mm. (Coutière, 1911*c*, pl. viii, fig. 1).

Organ of fixation: A cylindrical hollow stalk terminating inside the host as a blunt cone.

(3) *Amallocystis fasciatus* Fage

Hosts and manner of attachment: *Gnathophausia zoea* Will.-S., ventral surface of first abdominal segment. Also on *Gnathophausia ingens* (Dohrn).

Number and arrangement of trophomeres: About 150, arranged in tufts of five or six, with short stalks attached to the external part of the organ of fixation. Total length of the trophomeres with their gonomeres 1·5 mm.

Shape of trophomeres and gonomeres: Trophomeres cylindrical, gonomeres oval, the latter twice as long as broad or slightly more elongated.

Number of gonomeres on each trophomere: As a rule one, rarely two or three.

Dimensions of gonomeres: Transverse diameter 0·2 mm.

Organ of fixation: Showing a number of excrescences terminating with blunt extremities into the tissues of the host; one excrescence much larger than the others, pointing in anterior direction of the host.

(4) *Amallocystis umbellatus* n.sp., type specimen

Host and manner of attachment: *Hoplophorus grimaldii* Coutière, ventral surface of first abdominal segment.

Number and arrangement of trophomeres: About 750–1500 trophomeres in tufts of ten to twenty, each tuft with a long slender stalk attached to external part of organ of fixation.

Shape of trophomeres and gonomeres: Trophomeres conical to cylindrical, gonomeres globular, the distal gonomere somewhat elongated.

Number of gonomeres on each trophomere: Two or three (as a rule three).

Dimensions of gonomeres: Transverse diameter 165–225μ.

Organ of fixation: External part broadened, dividing into the basal parts of the stalks. Internal part more or less globular, with one long pointed excrescence extending in anterior direction of host. External and internal parts of organ of fixation connected by a somewhat narrower neck. Between proximal part of root system and organ of fixation a sieve plate.

(5) *Amallocystis umbellatus* n.sp., second specimen

Host and manner of attachment: *Hoplophorus novae-zeelandiae* De Man, ventral surface of abdomen, in integument joining first and second segments.

Number and arrangement of trophomeres: About 500, in tufts of ten to twenty, each tuft with a long slender stalk attached to external part of organ of fixation.

Shape of trophomeres and gonomeres: Trophomeres conical to cylindrical, gonomeres globular, the distal gonomere somewhat elongated.

Number of gonomeres on each trophomere: Two or three (as a rule three).

Dimensions of gonomeres: Transverse diameter 140–195μ.

Organ of fixation: Not examined.

(6) *Amallocystis capillosus* Fage, type specimens

Host and manner of attachment: *Pasiphaea tarda* Kröyer, base of rostrum.

Number and arrangement of trophomeres: About fifty, in two bundles, at each side of the rostrum of the host one.

Shape of trophomeres and gonomeres: Trophomeres with long slender stalks, cylindrical or basal part conical, length 1–1·3 mm., diameter 0·25 mm. (Fage, 1938, text, 0·025 mm.; ibid., fig. 2, 0·25 mm.). Gonomeres cylindrical.

Number of gonomeres on each trophomere: Not more than one.

Dimensions of gonomeres: Transverse diameter 0·25 mm. Length twice the breadth or more.

Organ of fixation: A hyaline plate with rough surface, in transverse position under the rostrum, extending at each side into an excrescence penetrating through the cuticle of the host.

(7) *Amallocystis capillosus* Fage, specimens from the Discovery collections

Host and manner of attachment: *Pasiphaea acutifrons* Bate, base of rostrum.

Number and arrangement of trophomeres: About fifty to seventy (originally probably more), arranged in two tufts each to one side of the rostrum.

Shape of trophomeres and gonomeres: Trophomeres more or less cylindrical with a proximal part tapering into the long slender stalk; gonomeres elongately oval. Trophomeres about twice as long as gonomeres.

Number of gonomeres on each trophomere: Not more than one.

Dimensions of gonomeres: Length about 0·6 mm., transverse diameter from 0·15 to 0·25 mm.

Organ of fixation: Irregularly globular, in its upper part with excrescences penetrating through the cuticle of the host, in its lower part possessing a sieve plate forming the connexion of the organ of fixation with the proximal part of the root system.

(8) *Amallocystis* sp., Einarsson (*Amallocystis fagei* Boschma)

Hosts and manner of attachment: *Thysanoessa inermis* (Kröyer) and *Th. raschii* (M. Sars), dorsal surface of the carapace in the region of the genital gland or (exceptionally) in the region of the stomach. As a rule more than one parasite on each host.

Number and arrangement of trophomeres: Numerous trophomeres (about thirty ?) spreading from the external part of the organ of fixation.

Shape of trophomeres and gonomeres: Trophomeres conical to cylindrical, gonomeres globular to oval.

Number of gonomeres on each trophomere: Up to nine (from one to ten constrictions in the sausage-like elongations, Einarsson, loc. cit.).

Dimensions of gonomeres: Transverse diameter approximately 100μ (measured in fig. 83 of Einarsson, loc. cit.).

Organ of fixation: Consisting of an internal irregularly oval part and an external part divided into the basal extremities of the trophomeres, the two parts connected by a rather narrow neck.

(9) *Amallocystis fagei* Boschma, specimens from the Discovery collections

Hosts and manner of attachment: *Euphausia vallentini* Stebbing, *E. frigida* H. J. Hansen, *E. recurva* H. J. Hansen, *E. lucens* H. J. Hansen, *E. hemigibba* H. J. Hansen, *Thysanoessa gregaria* G. O. Sars. Dorsal surface of carapace in the region of the genital gland.

Number and arrangement of trophomeres: Parasites of *Euphausia vallentini* and *E. frigida*, thirty to fifty; parasites of *E. recurva*, *E. lucens*, *E. hemigibba* and *Thysanoessa gregaria*, ten to fifteen. In a single tuft spreading from the external part of the organ of fixation.

Shape of trophomeres and gonomeres: Trophomeres conical to cylindrical, gonomeres more or less globular, the distal gonomere often somewhat elongated.

Number of gonomeres on each trophomere: Up to seven.

Dimensions of gonomeres: Parasites of *Euphausia vallentini* and *E. frigida*, transverse diameter 0·16–0·33 mm.; parasites of *E. hemigibba*, *E. recurva* and *Thysanoessa gregaria*, transverse diameter 0·13–0·16 mm.

Organ of fixation: External part broadened, dividing into the basal parts of the stalks, internal part globular or oval; the two parts united by a neck which, as a rule, is rather narrow. In a specimen on *Th. gregaria* the internal part of the organ of fixation has a pointed excrescence directed towards the posterior region of the host. Sieve plate in the lower part of the organ of fixation.

The data compiled above show that the species of *Amallocystis* can easily be characterized by means of their external parts only. These characters are the following.

Amallocystis fagei Boschma. Trophomeres each with a separate short stalk extending from the external part of the organ of fixation. Trophomeres with rather numerous (up to seven or eight) gonomeres, the latter of globular shape, not more than slightly longer than broad.

Amallocystis racemosus Coutière. Trophomeres each with a separate short stalk extending from the external part of the organ of fixation. Trophomeres with rather numerous (up to seven) gonomeres, the latter of oval shape, about twice as long as broad.

Amallocystis fasciatus Fage. Trophomeres in tufts of five or six, each tuft with a short stalk attached to the external part of the organ of fixation. Trophomeres with one, rarely with two or three gonomeres; the latter oval, twice as long as broad or slightly more elongated.

Amallocystis umbellatus n.sp. Trophomeres in tufts of ten to twenty, each tuft with a long stalk attached to the external part of the organ of fixation. Trophomeres with two or three (usually three) gonomeres of globular or slightly oval shape.

Amallocystis capillosus Fage. Trophomeres with long thin stalks, each more or less separately originating from the external part of the organ of fixation. Trophomeres with one gonomere of cylindrical shape. Gonomeres twice as long as broad or still more elongate.

Coutière regarded the specimen mentioned by Bate, the parasite of *Pasiphaea cristata* Bate, as a representative of his species *Amallocystis racemosus*, parasitic on *Pasiphaea tarda* Kröyer. The two specimens, indeed, have much in common. Both show approximately the same number of trophomeres; they are attached to their hosts in approximately the same spot (Bate's specimen on the second abdominal segment, Coutière's specimen on the third). The number of gonomeres occurring on the trophomeres, however, is different in the two specimens. In Bate's specimen in both of his drawings (Bate, 1888, pl. cxl, figs. 3, 3′) the trophomeres invariably bear three gonomeres, whilst in Coutière's specimen this number is variable, up to seven. It is, therefore, not altogether certain that the two parasites really belong to the same species.

The two specimens of *Amallocystis umbellatus* are slightly different. The specimen on *Hoplophorus grimaldii* Coutière has a far greater number of trophomeres than the one on *H. novae-zeelandiae* De Man, though this difference certainly does not point to a specific difference of the two. The host of the larger specimen is about twice the size of the host of the smaller specimen, which may be the reason for the more luxuriant development of the larger specimen. Further, it is not impossible that the smaller specimen had not yet reached its full size. It is of minor importance that the diameter of the trophomeres and the gonomeres in the smaller specimen is smaller than that found in the larger specimen.

Differences of this kind are of common occurrence in the various specimens of *Amallocystis fagei*. In connexion with the size of the host this species shows a strong variation in the number of the

trophomeres and in the dimensions of the trophomeres and the gonomeres. Gonomeres of small specimens may be less than half as long and broad as those of large specimens. The measurements of specimens on *Thysanoessa* from Icelandic waters were taken from the figures in Einarsson's paper (1945, fig. 83*b*, *c*). If these measurements (0·1 mm.) are correct the trophomeres and gonomeres of these Icelandic specimens are still smaller than those of the parasites on *Thysanoessa* from the Antarctic (0·13–0·16 mm.). For the present it must remain undecided whether the Arctic form really is specifically the same as the Antarctic form. The available data point to a specific unity.

The specimens of *Amallocystis capillosus* dealt with in the present paper correspond in all important characters with the specimens described by Fage. The trophomeres and gonomeres have the same shape and approximately the same dimensions. It is interesting that the specimen described in detail in the present paper pierces one side of the base of the rostrum of its host in two separate places. Undoubtedly normally there is one of these holes only at each side of the rostrum, as in the specimens described by Fage.

THE GENERA OF THE FAMILY ELLOBIOPSIDAE

The data obtained in the examination of the three species of the genus *Amallocystis* dealt with in the present paper give occasion for a comparison of these results with the data in the literature concerning the other genera of the Ellobiopsidae. The most striking fact presenting itself is the similarity of the genera *Ellobiopsis* and *Amallocystis*. With these two the genus *Rhizellobiopsis* seems to form one group. The comparatively little-known genus *Ellobiocystis* appears to be rather distinct from the group of three genera mentioned above, and the genus *Parallobiopsis* differs sufficiently from all the other genera of the family for it to be regarded it as a distinct group by itself. The arguments for this division of the family into different groups may be set forth in more detail.

In fully developed specimens of *Ellobiopsis chattoni* the external part may have a length of 700μ and a transverse diameter of 350μ. Then the pear-shaped external part is divided into a smaller trophomere and a larger gonomere (Caullery, 1910; Jepps, 1937), the gonomere being about twice as long as the trophomere, or having at least twice the volume of the trophomere. The parasite is attached to one of the anterior appendages of its host by a distinct organ of fixation which as a strong rod penetrates into the appendage. Apparently it is not only an organ of fixation but has also the function of absorbing the food.

The specimen of *E. chattoni* described and figured by Steuer (1928, 1932*b*, 1933), and regarded by him as an adult stage, shows a large pear-shaped trophomere capped by a much smaller globular gonomere, the length of the trophomere being 311μ, that of the gonomere 111μ. Moreover, in Steuer's specimen the groove between the gonomere and the trophomere is much more pronounced than in Caullery's specimens. The specimens figured by Apstein (1911) and by Willey (1920) show a small gonomere separated by a distinct groove from the much larger trophomere; in these respects they correspond with Steuer's specimen. The differences between the two forms possibly point to a specific distinction. For the present this must remain undecided.

An undoubtedly specifically separate form is *E. elongata* Steuer (1932*a*). When fully developed it consists of a cylindrical trophomere with a length of 250μ, and at the top of this trophomere are two globular gonomeres with a diameter of 70–80μ. Besides being much smaller than *E. chattoni* this parasite is distinguished by its peculiar shape. As in *E. chattoni* the stalk penetrates into the appendage of the host as a long thin organ of fixation.

The external part of *E. chattoni*, and even more distinctly that of *E. elongata*, closely corresponds with one of the external excrescences of the species of the genus *Amallocystis*. Principally *Amallocystis* is nothing but a compound *Ellobiopsis*, in which the organ of fixation has become more complicated

to ensure a strong fixation into the host and to develop into a strongly divided organ for the absorption of the food.

Amallocystis fagei, the species with the comparatively small number of trophomeres, is of a much more simple structure than the other species of the genus. The more or less complicated structure of the latter can be easily explained as modifications of the organization of *A. fagei*.

Rhizellobiopsis, the genus established by Hovassse (1926) for the parasite of the Annelid *Nephthys ciliata*, described by Zachs (1923) as *Ellobiopsis* (?) *eupraxiae*, is very similar to *Ellobiopsis*. The body consists of a rather large trophomere and a number of gonomeres (four in Zachs's figure). The distal gonomere in the figured specimen shows a kind of sporulation reminiscent of that described by Jepps (1937) in *E. chattoni*. *Rhizellobiopsis* differs from *Ellobiopsis* by its more or less dichotomously divided root system, but in other respects it has a strong resemblance to the species of *Ellobiopsis*, especially to *E. elongata*, in which two gonomeres develop on the top of the gonomere.

Of the various species described by Coutière (1911*c*) in his genus *Ellobiocystis*, very little is known besides their external shape. It seems to be certain that all these forms are simply attached to the cuticle of their hosts without penetrating into it. They are, therefore, no real parasites, but appear to lead a saprophytic mode of life.

Parallobiopsis coutieri Collin, which has been the subject of extensive studies by Hovasse (1926), is an organism which differs in many respects from *Ellobiopsis* and from *Amallocystis*. This parasite is attached to the cuticle of its host by a well-developed sucker. In the central part of this sucker the cuticle of the host is pierced, and here a protoplasmatic excrescence of the parasite penetrates into the tissues, thereby forming an organ for the absorption of food. The body of the parasite is divided by transverse septa into up to eight or nine divisions, the basal of which is the trophomere. At the top of the latter there are a few flat recently formed young gonomeres. Towards the free extremity the gonomeres gradually become larger, so that the distal gonomere is longer than broad.

Various opinions have been expressed concerning the place of the Ellobiopsidae in the classification of the Protozoa. Caullery (1910) was inclined to regard his genus *Ellobiopsis* as a parasitic Peridinean, and with some doubt it is included in this group in Chatton's (1920) monograph of the parasitic Peridinea. After Hovasse (1925*a*) had found that the spores of *Parallobiopsis* are flagellispores, he advocated the view that the Ellobiopsidae form a specialized group of the Flagellata. Afterwards also Steuer classified the Ellobiopsidae among the Flagellata. An entirely different view was expressed by Jepps (1937, p. 642): 'the information at present available seems to me to suggest a fungus relationship rather than any other—although perhaps such speculation is at present unprofitable.'

In the present paper no results are given of cytological details which might point to the affinities of the Ellobiopsidae with other groups of organisms. The particulars referred to above, however, might indicate that the genera which now are included in the family Ellobiopsidae do not form an altogether homogeneous group. It seems probable that especially *Parallobiopsis* is very little allied to *Ellobiopsis* and *Amallocystis*, and, consequently, when it is a fact that *Parallobiopsis* belongs to the Flagellata it is not yet certain that *Ellobiopsis* and *Amallocystis* too must be regarded as Flagellates. As long as no particulars concerning the sporulation of the last-named genera of more definite value than those at present available become known, no distinct indications in regard to their systematic position can be put forward.

GEOGRAPHICAL DISTRIBUTION OF THE ELLOBIOPSIDAE

In its typical form *Ellobiopsis chattoni* Caullery was once collected at Banyuls-sur-mer in the Mediterranean, and on several occasions in the region of the Firth of Clyde. If really all the parasites of this genus consisting of one trophomere with one gonomere which were described or mentioned by various

authors belong to *E. chattoni*, the species has a more or less world-wide distribution, as shown on the map in Steuer's (1932*b*) paper. *E. elongata* Steuer is known from one locality only, in the South Atlantic in the South Georgia region.

The specimens belonging to the genus *Ellobiocystis* were all collected in the region from the Bay of Biscay to the Azores. *Parallobiopsis* is known from the Mediterranean coastal waters of France only. *Rhizellobiopsis* was found in the material of two stations of the expedition of Prof. Deruguine in the White Sea. These seemingly restricted areas probably do not constitute the real regions of distribution of the genera mentioned here.

The available data concerning the distribution of the compound Ellobiopsidae seem to point to the fact that all these are of world-wide occurrence.

Amallocystis racemosus (Coutière) was found in the region to the north-east of Iceland. The Ellobiopsid mentioned and figured by Bate, and regarded by Coutière as belonging to *A. racemosus*, came from the region of the Fiji Islands.

A. fasciatus Fage is known from the Pacific (off New Zealand and the Fiji Islands), from the Atlantic, and from the Indian Ocean.

A. capillosus Fage is known to occur in the Skagerrak (Fage, 1938) and in the Strait of Magellan (specimens dealt with in the present paper).

The two specimens of *A. umbellatus* n.sp. are both from the Atlantic, one from the tropical region, east of Brazil, the other from the South Atlantic, west of Capetown.

The specimens of *A. fagei* Boschma dealt with in the present paper were all collected in the southern hemisphere and mostly in the Antarctic region. Some of them are from the South Atlantic: off South Brazil (St. 712), off Patagonia (St. WS 770), and Scotia Sea and off South Georgia (St. 665, 748, 751, 766, 1056). Others are from the South Pacific: Bellingshausen Sea (St. 733), and about half-way between New Zealand and Tierra del Fuego (St. 963, 965). Others again are from the South Indian Ocean: south of Australia (St. 892), and south-west of Australia (St. 869, 871, 872). *Amallocystis* sp., reported upon by Einarsson (1945), occurring in the waters around Iceland, in all probability belongs to *A. fagei*. It is probable that the specimen mentioned by Macdonald (1927) from Cumbrae Deep in the Firth of Clyde also belonged to the same species. This species then would also have a large area of distribution.

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PLATE XXXVIII

Amallocystis fagei Boschma

Figs. 1–3. Specimens on *Euphausia vallentini* Stebbing from St. WS 770. Side view of host. ×6.

Fig. 4. Specimen of fig. 1. Dorsal view of host. ×6.

Fig. 5. Specimen of fig. 2. Dorsal view of host. ×6.

Fig. 6. Specimen on *Euphausia recurva* H. J. Hansen from St. 712. Side view of host. ×6.

Fig. 7. Specimen on *Thysanoessa gregaria* G. O. Sars from St. 965. Side view of host. ×6.

Fig. 8. Specimen on *Euphausia frigida* H. J. Hansen from St. 751. Side view of host. ×6.

Fig. 9. Specimen on *Euphausia hemigibba* H. J. Hansen from St. 872. Side view of host. ×6.

Fig. 10. Specimen of fig. 2. ×21.

Fig. 11. Specimen of fig. 8. ×21.

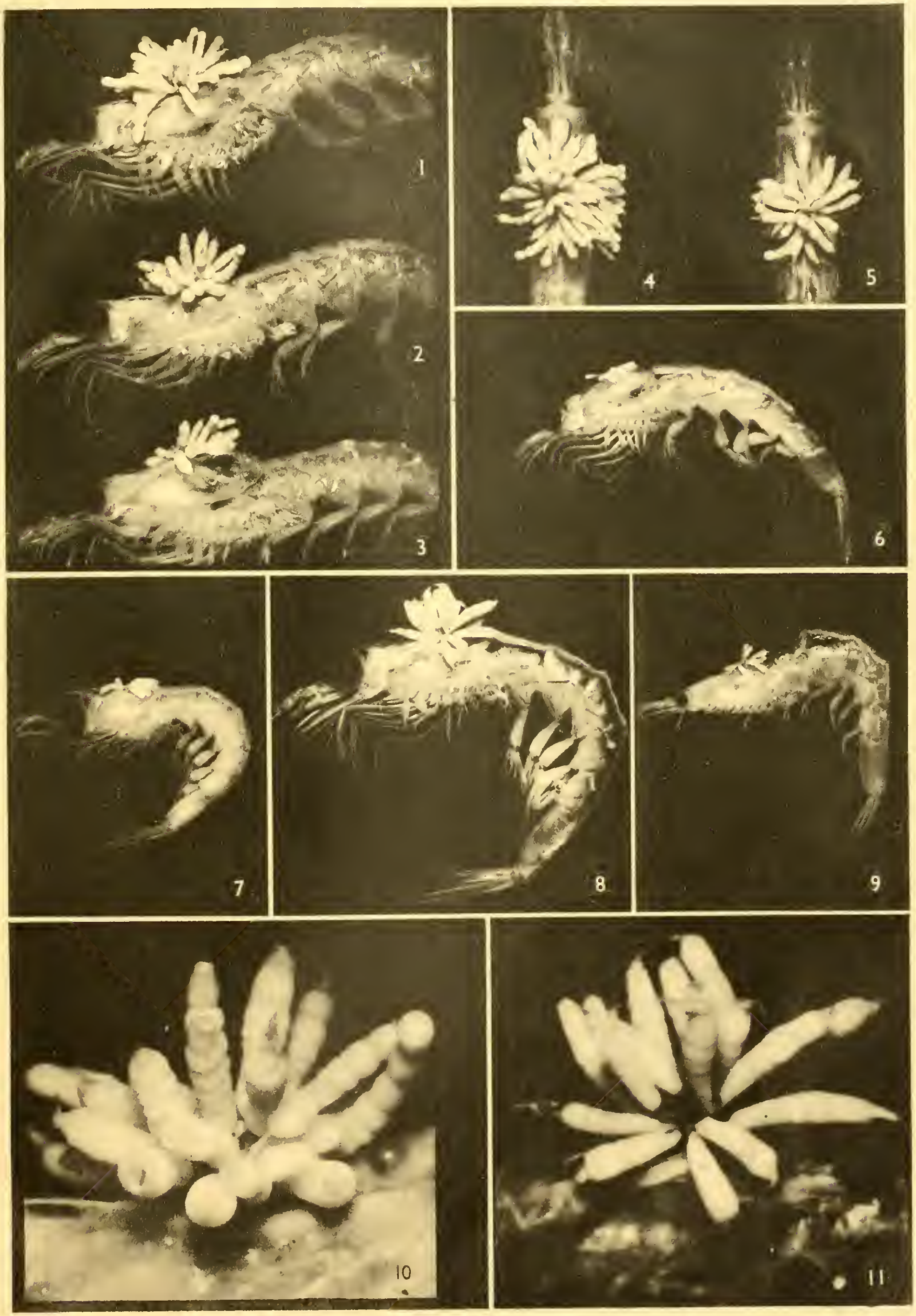
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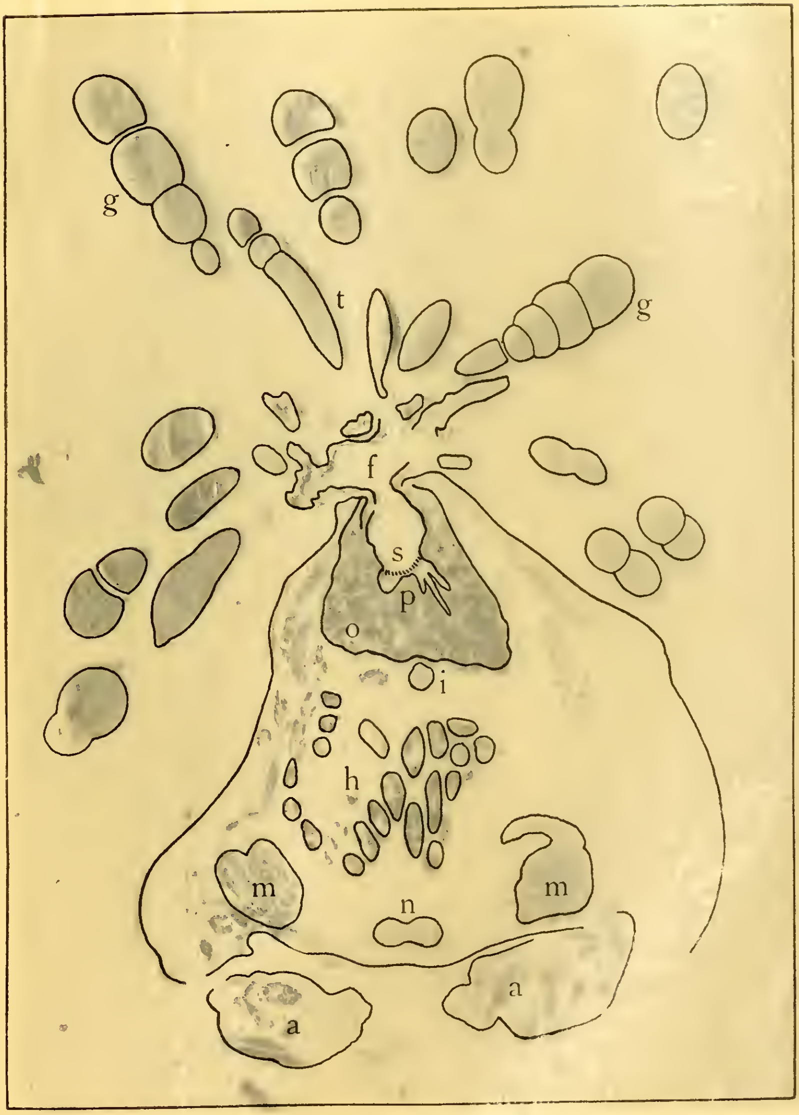
PLATE XXXIX

Transverse section of *Euphausia vallentini* Stebbing with *Amallocystis fagei* Boschma from St. WS 770. *a*, appendages of host; *f*, organ of fixation; *g*, gonomere; *h*, hepatopancreas of host; *i*, intestine of host; *m*, musculature of host; *n*, ventral nerve cord of host; *o*, ovary of host; *p*, protoplasmatic excrescences; *s*, sieve plate; *t*, trophomere. × 50.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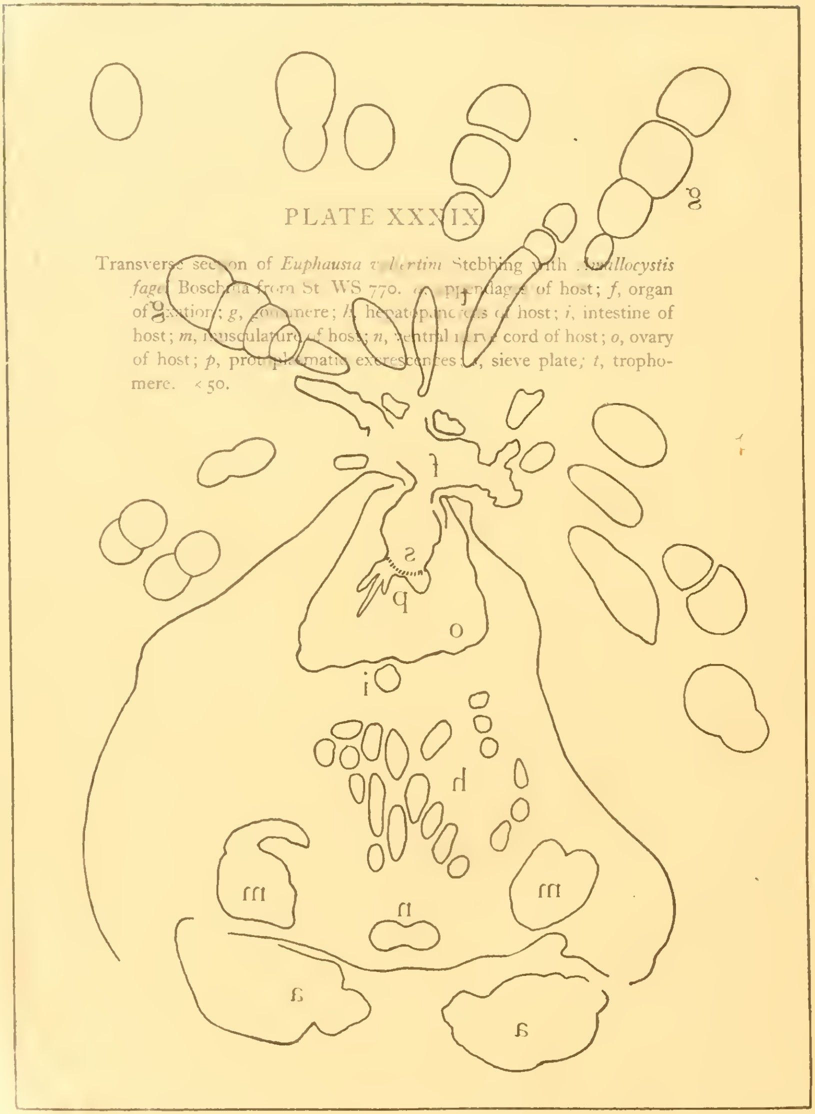

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Transverse section of *Euphausia vallentini* Stebbing with *Amallocystis fagei* Boschma from St. WS 770. *a*, appendages of host; *f*, organ of fixation; *g*, gonomere; *h*, hepatopancreas of host; *i*, intestine of host; *m*, musculature of host; *n*, ventral nerve cord of host; *o*, ovary of host; *p*, protoplasmatic excrescences; *s*, sieve plate; *t*, trophomere. × 50.

PLATE XL

Upper figure: longitudinal section of *Euphausia vallentini* Stebbing with two specimens of *Amallocystis fagei* Boschma from St. WS 770. ×61.

Lower figure: Part of next section of the same specimen. ×525. *c*, cuticle of host; *e f*, external part of organ of fixation; *f*, organ of fixation; *g*, gonomere; *h*, hepatopancreas of host; *ht*, heart of host; *m*, musculature of host; *o*, ovary of host; *p*, protoplasmatic excrescences; *s*, sieve plate; *st*, stomach of host; *t*, trophomere.


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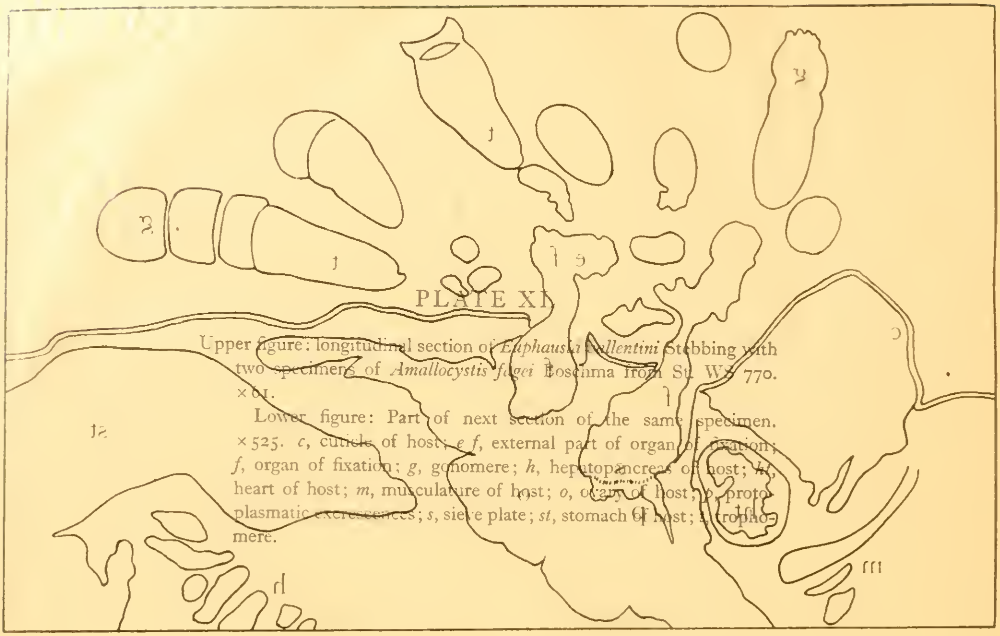
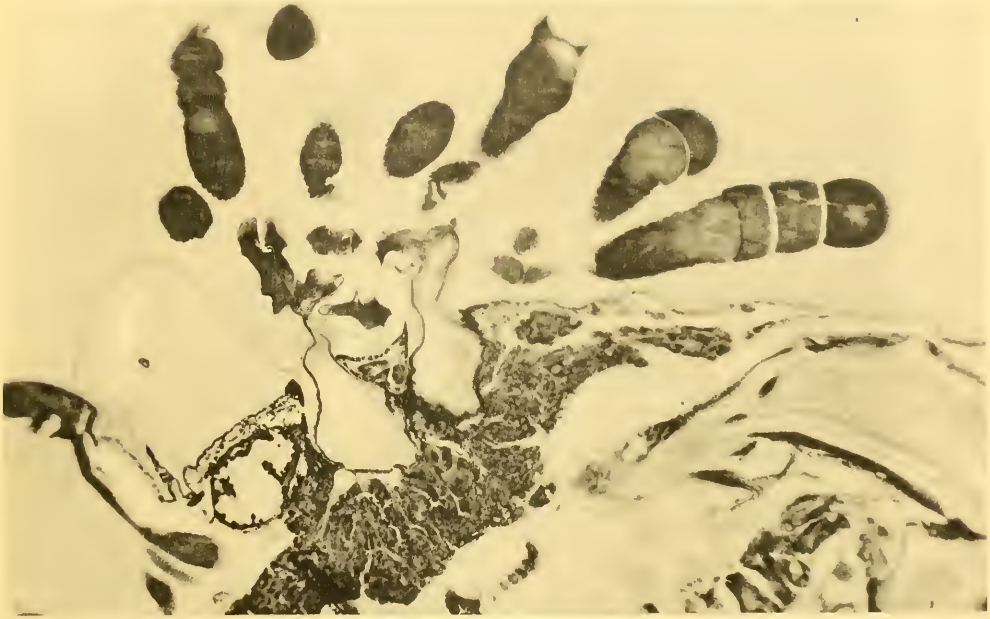


PLATE XI

Upper figure: longitudinal section of *Euphausia vallentini* Stebbing with two specimens of *Amallocystis fagei* Boschma from St. WS 770. ×61.

Lower figure: Part of next section of the same specimen. ×525. *c*, cuticle of host; *e f*, external part of organ of fixation; *f*, organ of fixation; *g*, gonomere; *h*, hepatopancreas of host; *ht*, heart of host; *m*, musculature of host; *o*, ovary of host; *p*, protoplasmatic excrescences; *s*, sieve plate; *st*, stomach of host; *t*, trophomere.



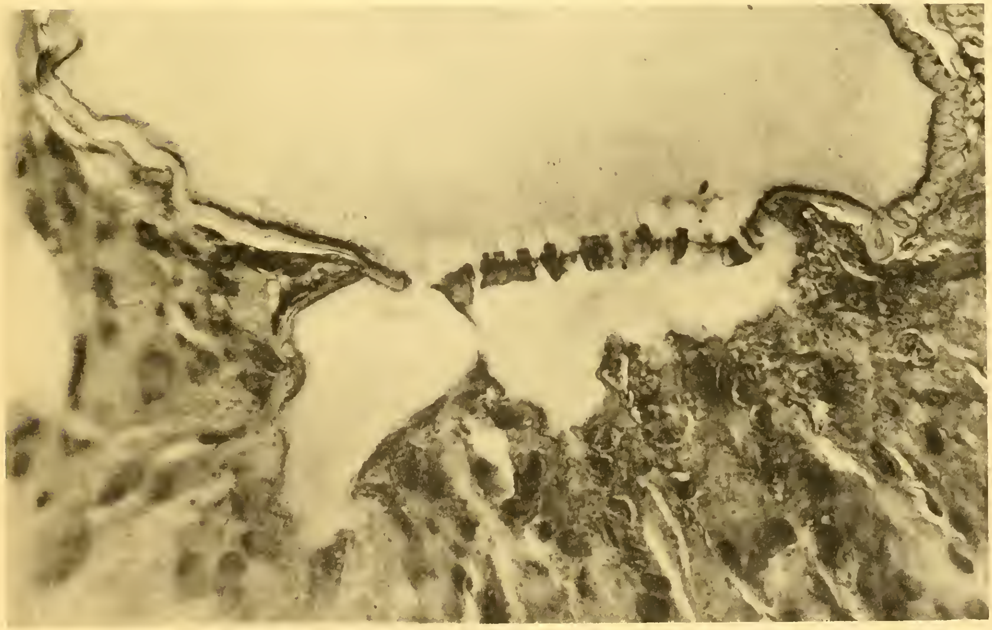


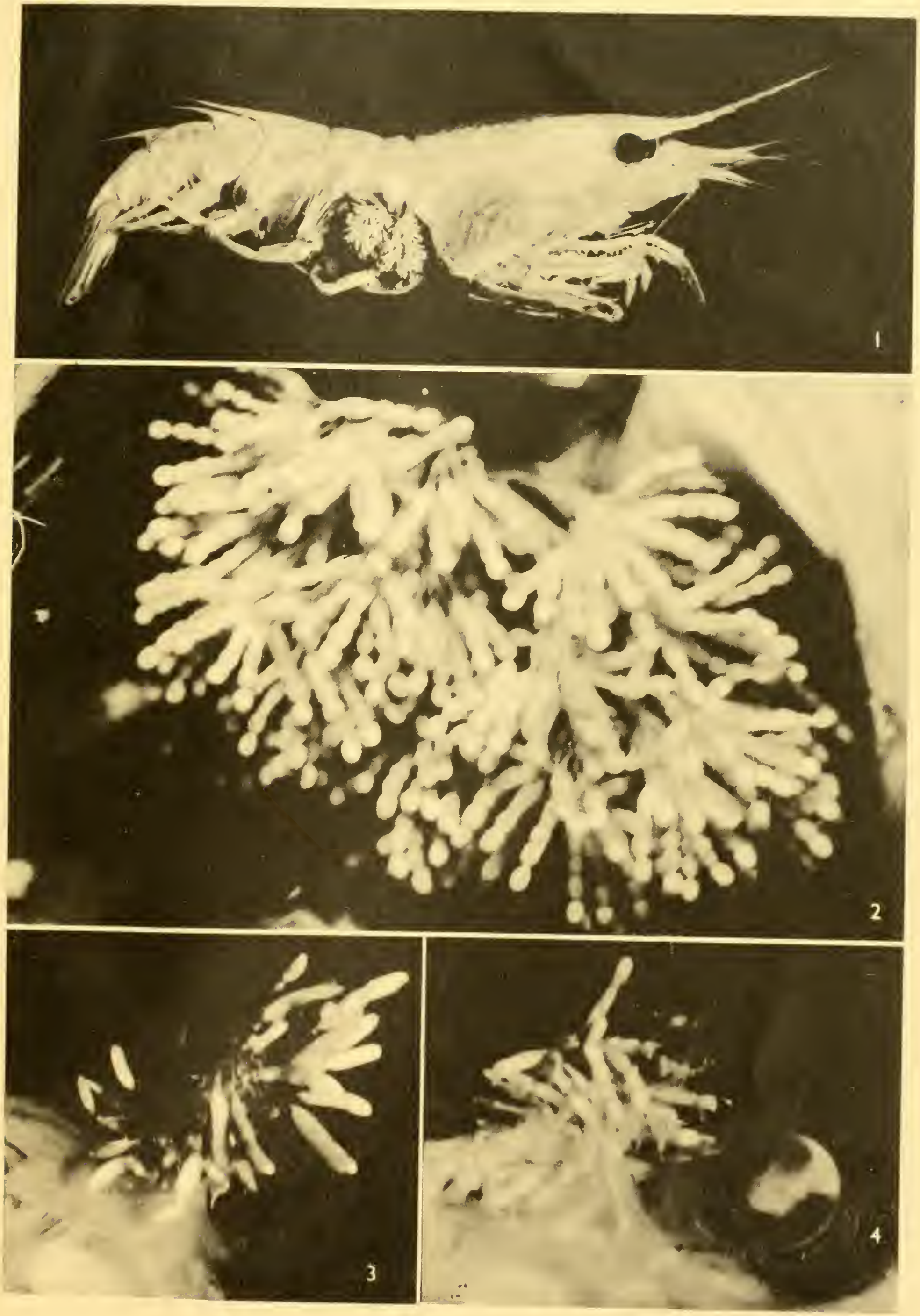
PLATE XLI

Fig. 1. *Hoplophorus grimaldii* Coutière with *Amallocystis umbellatus* n.sp. Slightly more than × 2.

Fig. 2. *Amallocystis umbellatus* n.sp. Same specimen. × 18.

Fig. 3. Rostral region of *Pasiphaea acutifrons* Bate with *Amallocystis capillosus* Fage. Approximately × 14.

Fig. 4. Rostral region of *Pasiphaea acutifrons* Bate with *Amallocystis capillosus* Fage. Sectioned specimen. Approximately × 14.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